
tenstrade Documentation

Release 0.2.0-beta.0

Adam King

Jan 31, 2020

Contents

1	Guiding principles	3
	Python Module Index	85
	Index	87



TensorTrade is an open source Python framework for building, training, evaluating, and deploying robust trading algorithms using reinforcement learning. The framework focuses on being highly composable and extensible, to allow the system to scale from simple trading strategies on a single CPU, to complex investment strategies run on a distribution of HPC machines.

Under the hood, the framework uses many of the APIs from existing machine learning libraries to maintain high quality data pipelines and learning models. One of the main goals of TensorTrade is to enable fast experimentation with algorithmic trading strategies, by leveraging the existing tools and pipelines provided by `numpy`, `pandas`, `gym`, `keras`, and `tensorflow`.

Every piece of the framework is split up into re-usable components, allowing you to take advantage of the general use components built by the community, while keeping your proprietary features private. The aim is to simplify the process of testing and deploying robust trading agents using deep reinforcement learning, to allow you and I to focus on creating profitable strategies.

The goal of this framework is to enable fast experimentation, while maintaining production-quality data pipelines.

Feel free to also walk through the [Medium tutorial](#).

CHAPTER 1

Guiding principles

Inspired by Keras' [guiding principles](#).

User friendliness. TensorTrade is an API designed for human beings, not machines. It puts user experience front and center. TensorTrade follows best practices for reducing cognitive load: it offers consistent & simple APIs, it minimizes the number of user actions required for common use cases, and it provides clear and actionable feedback upon user error.

Modularity. A trading environment is a conglomeration of fully configurable modules that can be plugged together with as few restrictions as possible. In particular, exchanges, feature pipelines, action schemes, reward schemes, trading agents, and performance reports are all standalone modules that you can combine to create new trading environments.

Easy extensibility. New modules are simple to add (as new classes and functions), and existing modules provide ample examples. To be able to easily create new modules allows for total expressiveness, making TensorTrade suitable for advanced research and production use.

1.1 Getting Started

You can get started testing on Google Colab or your local machine, by viewing our [many examples](#)

1.2 Installation

TensorTrade requires Python ≥ 3.6 for all functionality to work as expected.

You can install the package from PyPi via pip or from the Github repo.

```
pip install tensortrade
```

OR

```
pip install git+https://github.com/notadamking/tensortrade.git
```

Some functionality included in TensorTrade is optional. To install all optional dependencies, run the following command:

```
pip install tensortrade[tf,tensorforce,baselines,ccxt,fbm]
```

OR

```
pip install git+https://github.com/notadamking/tensortrade.git[tf,tensorforce,  
->baselines,ccxt,fbm]
```

1.3 Docker

To run the commands below ensure Docker is installed. Visit <https://docs.docker.com/install/> for more information

1.3.1 Run Jupyter Notebooks

To run a jupyter notebook execute the following

```
make run-notebook
```

which will generate a link of the form 127.0.0.1:8888/?token=... Paste this link into your browser and select the notebook you'd like to explore

1.3.2 Build Documentation

To build documentation execute the following

```
make run-docs
```

1.3.3 Run Test Suite

To run the test suite execute the following

```
make run-tests
```

1.4 Code Structure

The TensorTrade library is modular. The `tensortrade` library usually has a common setup:

1. An abstract `MetaABC` class that highlights the methods that will generally be called inside of the main `TradingEnvironment`.
2. Specific applications of that abstract class are then specified later to make more detailed specifications.

1.4.1 Example of Structure:

A good example of this structure is the `Exchange` component. It represents all exchange interactions.

The beginning of the code in `Exchange` is seen here.

```
class Exchange(object, metaclass=ABCMeta):
    """An abstract exchange for use within a trading environment."""

    def __init__(self, base_instrument: str = 'USD', dtype: Union[type, str] = np.
    ↪float32, feature_pipeline: FeaturePipeline = None):
        """
        Arguments:
            base_instrument: The exchange symbol of the instrument to store/measure_
    ↪value in.
            dtype: A type or str corresponding to the dtype of the `observation_
    ↪space`.
            feature_pipeline: A pipeline of feature transformations for transforming_
    ↪observations.
        """
        self._base_instrument = base_instrument
        self._dtype = dtype
        self._feature_pipeline = feature_pipeline
```

As you can see above, the `Exchange` has a large majority of the instantiation details that carries over to all other representations of that type of class. `ABCMeta` represents that all classes that inherit it shall be recognizable as an instance of `Exchange`. This is nice when you need to do type checking.

When creating a new exchange type (everything that's an inheritance of the `Exchange`), one needs to add further details for how information should be declared by default. Once you create a new type of exchange, you can have new rules placed in by default. Let's look at the `SimulatedExchange` and it can have parameters dynamically set via the `**kwargs` argument in later exchanges.

SimulatedExchange:

```
class SimulatedExchange(Exchange):
    """An exchange, in which the price history is based off the supplied data frame_
    ↪and
    trade execution is largely decided by the designated slippage model.
    If the `data_frame` parameter is not supplied upon initialization, it must be set_
    ↪before
    the exchange can be used within a trading environment.
    """

    def __init__(self, data_frame: pd.DataFrame = None, **kwargs):
        super().__init__(
            dtype=self.default('dtype', np.float32),
            feature_pipeline=self.default('feature_pipeline', None)
        )

        self._commission_percent = self.default('commission_percent', 0.3, kwargs)
        self._base_precision = self.default('base_precision', 2, kwargs)
        self._instrument_precision = self.default('instrument_precision', 8, kwargs)
        self._min_trade_size = self.default('min_trade_size', 1e-6, kwargs)
        self._max_trade_size = self.default('max_trade_size', 1e6, kwargs)

        self._initial_balance = self.default('initial_balance', 1e4, kwargs)
        self._observation_columns = self.default(
```

(continues on next page)

(continued from previous page)

```

        'observation_columns',
        ['open', 'high', 'low', 'close', 'volume'],
        kwargs
    )
    self._price_column = self.default('price_column', 'close', kwargs)
    self._window_size = self.default('window_size', 1, kwargs)
    self._pretransform = self.default('pretransform', True, kwargs)
    self._price_history = None

    self.data_frame = self.default('data_frame', data_frame)

    model = self.default('slippage_model', 'uniform', kwargs)
    self._slippage_model = slippage.get(model) if isinstance(model, str) else _
↪model()

```

Everything that inherits SimulatedExchange uses the specified kwargs to set the parameters.

Therefore, even when we don't directly see the parameters inside of FBMEExchange, all of the defaults are being called.

An example:

```

exchange = FBMEExchange(base_instrument='BTC', timeframe='1h', base_precision=4) # we
↪'re replacing the default base precision.

```

1.5 Train and Evaluate

```

[2]: from tensorforce.agents import Agent
      from tensorforce.environments import Environment

      from tenstrade.environments import TradingEnvironment
      from tenstrade.exchanges.simulated import FBMEExchange
      from tenstrade.features.scalers import MinMaxNormalizer
      from tenstrade.features.stationarity import FractionalDifference
      from tenstrade.features import FeaturePipeline
      from tenstrade.rewards import SimpleProfit
      from tenstrade.actions import DiscreteActions
      from tenstrade.strategies import TensorforceTradingStrategy

      normalize = MinMaxNormalizer(inplace=True)
      difference = FractionalDifference(difference_order=0.6,
                                       inplace=True)
      feature_pipeline = FeaturePipeline(steps=[normalize, difference])

      reward_scheme = SimpleProfit()
      action_scheme = DiscreteActions(n_actions=20, instrument='ETH/BTC')

      exchange = FBMEExchange(base_instrument='BTC',
                              timeframe='1h',
                              should_pretransform_obs=True)

      environment = TradingEnvironment(exchange=exchange,
                                      action_scheme=action_scheme,
                                      reward_scheme=reward_scheme,

```

(continues on next page)

(continued from previous page)

```

feature_pipeline=feature_pipeline)

agent_spec = {
    "type": "ppo_agent",
    "step_optimizer": {
        "type": "adam",
        "learning_rate": 1e-4
    },
    "discount": 0.99,
    "likelihood_ratio_clipping": 0.2,
}

network_spec = [
    dict(type='dense', size=64, activation="tanh"),
    dict(type='dense', size=32, activation="tanh")
]

strategy = TensorforceTradingStrategy(environment=environment, agent_spec=agent_spec,
↳network_spec=network_spec)

performance = strategy.run(episodes=1, testing=True)

performance[-5:]

```

WARNING: The TensorFlow contrib module will not be included in TensorFlow 2.0.
For more information, please see:
* [https://github.com/tensorflow/community/blob/master/rfcs/20180907-contrib-sunset.](https://github.com/tensorflow/community/blob/master/rfcs/20180907-contrib-sunset.md)
↳md
* <https://github.com/tensorflow/addons>
If you depend on functionality not listed there, please file an issue.

100%|| 1/1 [00:08<00:00, 8.94s/it]

Finished running strategy.
Total episodes: 1 (1666 timesteps).
Average reward: 1150.3350630537668.

```

[2]:
      balance    net_worth
1661  9999.829222  10000.187790
1662  9997.354264   9998.232905
1663  9994.879919   9995.990028
1664  9991.169320   9992.191048
1665  9991.535304   9992.226192

```

```

[4]: from tensortrade.environments import TradingEnvironment
from tensortrade.exchanges.simulated import FBMEExchange
from tensortrade.features.scalers import MinMaxNormalizer
from tensortrade.features.stationarity import FractionalDifference
from tensortrade.features import FeaturePipeline
from tensortrade.rewards import SimpleProfit
from tensortrade.actions import DiscreteActions
from tensortrade.strategies import StableBaselinesTradingStrategy

normalize = MinMaxNormalizer(inplace=True)
difference = FractionalDifference(difference_order=0.6,

```

(continues on next page)

(continued from previous page)

```

                                inplace=True)
feature_pipeline = FeaturePipeline(steps=[normalize, difference])

reward_scheme = SimpleProfit()
action_scheme = DiscreteActions(n_actions=20, instrument='ETH/BTC')

exchange = FBMEExchange(base_instrument='BTC',
                        timeframe='1h',
                        should_pretransform_obs=True)

environment = TradingEnvironment(exchange=exchange,
                                action_scheme=action_scheme,
                                reward_scheme=reward_scheme,
                                feature_pipeline=feature_pipeline)

strategy = StableBaselinesTradingStrategy(environment=environment)

performance = strategy.run(episodes=10)

performance[-5:]

```

```

Finished running strategy.
Total episodes: 10 (16660 timesteps).
Average reward: 1.1827063286237227.

```

```

[4]:
      balance    net_worth
1660  11226.614898  11227.750341
1661  11226.686075  11227.725535
1662  11226.721664  11227.658857
1663  11226.739458  11227.908940
1664  11223.960840  11225.188709

```

1.6 Components

TensorTrade is built around modular components that together make up a trading strategy. Trading strategies combine reinforcement learning agents with composable trading logic in the form of a `gym` environment. A trading environment is made up of a set of modular components that can be mixed and matched to create highly diverse trading and investment strategies.

Just like electrical components, the purpose of TensorTrade components is to be able to mix and match them as necessary.

1.7 Trading Environment

A trading environment is a reinforcement learning environment that follows OpenAI's `gym.Env` specification. This allows us to leverage many of the existing reinforcement learning models in our trading agent, if we'd like.

Trading environments are fully configurable `gym` environments with highly composable `Exchange`, `FeaturePipeline`, `ActionScheme`, and `RewardScheme` components.

- The `Exchange` provides observations to the environment and executes the agent's trades.
- The `FeaturePipeline` optionally transforms the exchange output into a more meaningful set of features before it is passed to the agent.

- The `ActionScheme` converts the agent's actions into executable trades.
- The `RewardScheme` calculates the reward for each time step based on the agent's performance.

That's all there is to it, now it's just a matter of composing each of these components into a complete environment.

When the `reset` method of a `TradingEnvironment` is called, all of the child components will also be reset. The internal state of each exchange, feature pipeline, transformer, action scheme, and reward scheme will be set back to their default values, ready for the next episode.

Let's begin with an example environment. As mentioned before, initializing a `TradingEnvironment` requires an exchange, an action scheme, and a reward scheme, the feature pipeline is optional.

```
from tenstrade.environments import TradingEnvironment

environment = TradingEnvironment(exchange=exchange,
                                action_scheme=action_scheme,
                                reward_scheme=reward_scheme,
                                feature_pipeline=feature_pipeline)
```

1.8 Exchange

Exchanges determine the universe of tradable instruments within a trading environment, return observations to the environment on each time step, and execute trades made within the environment. There are two types of exchanges: live and simulated.

Live exchanges are implementations of `Exchange` backed by live pricing data and a live trade execution engine. For example, `CCXTExchange` is a live exchange, which is capable of returning pricing data and executing trades on hundreds of live cryptocurrency exchanges, such as Binance and Coinbase.

```
import ccxt
from tenstrade.exchanges.live import CCXTExchange

coinbase = ccxt.coinbasepro()
exchange = CCXTExchange(exchange=coinbase, base_instrument='USD')
```

There are also exchanges for stock and ETF trading, such as `RobinhoodExchange` and `InteractiveBrokersExchange`, but these are still works in progress.

Simulated exchanges, on the other hand, are implementations of `Exchange` backed by simulated pricing data and trade execution.

For example, `FBMExchange` is a simulated exchange, which generates pricing and volume data using fractional brownian motion (FBM). Since its price is simulated, the trades it executes must be simulated as well. The exchange uses a simple slippage model to simulate price and volume slippage on trades, though like almost everything in `TensorTrade`, this slippage model can easily be swapped out for something more complex.

```
from tenstrade.exchanges.simulated import FBMExchange

exchange = FBMExchange(base_instrument='BTC', timeframe='1h')
```

Though the `FBMExchange` generates fake price and volume data using a stochastic model, it is simply an implementation of `SimulatedExchange`. Under the hood, `SimulatedExchange` only requires a `data_frame` of price history to generate its simulations. This `data_frame` can either be provided by a coded implementation such as `FBMExchange`, or at runtime.

```
import pandas as pd
from tenstrade.exchanges.simulated import SimulatedExchange

df = pd.read_csv('./data/btc_ohclv_1h.csv')
exchange = SimulatedExchange(data_frame=df, base_instrument='USD')
```

1.9 Feature Pipeline

Feature pipelines are meant for transforming observations from the environment into meaningful features for an agent to learn from. If a pipeline has been added to a particular exchange, then observations will be passed through the `FeaturePipeline` before being output to the environment.

For example, a feature pipeline could normalize all price values, make a time series stationary, add a moving average column, and remove an unnecessary column, all before the observation is returned to the agent.

Feature pipelines can be initialized with an arbitrary number of comma-separated transformers. Each `FeatureTransformer` needs to be initialized with the set of columns to transform, or if nothing is passed, all input columns will be transformed.

Each feature transformer has a `transform` method, which will transform a single observation (a `pandas.DataFrame`) from a larger data set, keeping any necessary state in memory to transform the next frame. For this reason, it is often necessary to reset the `FeatureTransformer` periodically. This is done automatically each time the parent `FeaturePipeline` or `Exchange` is reset.

```
from tenstrade.features import FeaturePipeline
from tenstrade.features.scalars import MinMaxNormalizer
from tenstrade.features.stationarity import FractionalDifference
from tenstrade.features.indicators import SimpleMovingAverage

price_columns = ["open", "high", "low", "close"]
normalize_price = MinMaxNormalizer(price_columns)
moving_averages = SimpleMovingAverage(price_columns)
difference_all = FractionalDifference(difference_order=0.6)
feature_pipeline = FeaturePipeline(steps=[normalize_price,
                                         moving_averages,
                                         difference_all])

exchange.feature_pipeline = feature_pipeline
```

This feature pipeline normalizes the price values between 0 and 1, before adding some moving average columns and making the entire time series stationary by fractionally differencing consecutive values.

1.10 Action Scheme

Action schemes define the action space of the environment and convert an agent's actions into executable trades.

For example, if we were using a discrete action space of 3 actions (0 = hold, 1 = buy 100 %, 2 = sell 100%), our learning agent does not need to know that returning an action of 1 is equivalent to buying an instrument. Rather, our agent needs to know the reward for returning an action of 1 in specific circumstances, and can leave the implementation details of converting actions to trades to the `ActionScheme`.

Each action scheme has a `get_trade` method, which will transform the agent's specified action into an executable `Trade`. It is often necessary to store additional state within the scheme, for example to keep track of the currently

traded position. This state should be reset each time the action scheme's reset method is called, which is done automatically when the parent TradingEnvironment is reset.

```
from tenstrade.actions import DiscreteActions

action_scheme = DiscreteActions(n_actions=20, instrument='BTC')
```

This discrete action scheme uses 20 discrete actions, which equates to 4 discrete sizes for each of the 5 trade types (market buy/sell, limit buy/sell, and hold). E.g. [0,5,10,15]=hold, 1=market buy 25%, 2=market sell 25%, 3=limit buy 25%, 4=limit sell 25%, 6=market buy 50%, 7=market sell 50%, etc...

1.11 Reward Scheme

Reward schemes receive the Trade taken at each time step and return a float, corresponding to the benefit of that specific action. For example, if the action taken this step was a sell that resulted in positive profits, our RewardScheme could return a positive number to encourage more trades like this. On the other hand, if the action was a sell that resulted in a loss, the scheme could return a negative reward to teach the agent not to make similar actions in the future.

A version of this example algorithm is implemented in SimpleProfit, however more complex schemes can obviously be used instead.

Each reward scheme has a get_reward method, which takes in the trade executed at each time step and returns a float corresponding to the value of that action. As with action schemes, it is often necessary to store additional state within a reward scheme for various reasons. This state should be reset each time the reward scheme's reset method is called, which is done automatically when the parent TradingEnvironment is reset.

```
from tenstrade.rewards import SimpleProfit

reward_scheme = SimpleProfit()
```

The simple profit scheme returns a reward of -1 for not holding a trade, 1 for holding a trade, 2 for purchasing an instrument, and a value corresponding to the (positive/negative) profit earned by a trade if an instrument was sold.

1.12 Trading Strategy

A TradingStrategy consists of a learning agent and one or more trading environments to tune, train, and evaluate on. If only one environment is provided, it will be used for tuning, training, and evaluating. Otherwise, a separate environment may be provided at each step.

```
from stable_baselines import PPO2

from tenstrade.strategies import TensorforceTradingStrategy,
                                StableBaselinesTradingStrategy

agent_spec = {
    "type": "ppo_agent",
    "step_optimizer": {
        "type": "adam",
        "learning_rate": 1e-4
    },
    "discount": 0.99,
    "likelihood_ratio_clipping": 0.2,
```

(continues on next page)

(continued from previous page)

```

}

network_spec = [
    dict(type='dense', size=64, activation="tanh"),
    dict(type='dense', size=32, activation="tanh")
]

a_strategy = TensorforceTradingStrategy(environment=environment,
                                       agent_spec=agent_spec,
                                       network_spec=network_spec)

b_strategy = StableBaselinesTradingStrategy(environment=environment,
                                             model=PPO2,
                                             policy='MlpLnLSTMPolicy')

```

1.13 TradingEnvironment

A trading environment is a reinforcement learning environment that follows OpenAI's `gym.Env` specification. This allows us to leverage many of the existing reinforcement learning models in our trading agent, if we'd like.

`TradingEnvironment` steps through the various interfaces from the `tenstrade` library in a consistent way, and will likely not change too often as all other parts of `tenstrade` changes. We're going to go through an overview of the Trading environment below.

Trading environments are fully configurable `gym` environments with highly composable `Exchange`, `FeaturePipeline`, `ActionScheme`, and `RewardScheme` components.

- The `Exchange` provides observations to the environment and executes the agent's trades.
- The `FeaturePipeline` optionally transforms the exchange output into a more meaningful set of features before it is passed to the agent.
- The `ActionScheme` converts the agent's actions into executable trades.
- The `RewardScheme` calculates the reward for each time step based on the agent's performance.

That's all there is to it, now it's just a matter of composing each of these components into a complete environment.

When the `reset` method of a `TradingEnvironment` is called, all of the child components will also be reset. The internal state of each exchange, feature pipeline, transformer, action scheme, and reward scheme will be set back to their default values, ready for the next episode.

Let's begin with an example environment. As mentioned before, initializing a `TradingEnvironment` requires an exchange, an action scheme, and a reward scheme, the feature pipeline is optional.

1.13.1 OpenAI Gym Primer

Usually the OpenAI gym runs in the following way:

```

# Declare the environment
env = TrainingEnvironment()
# Declare and agent with an action_space, usually declared inside of the environment_
↪ itself
agent = RandomAgent(env.action_space)
reward = 0

```

(continues on next page)

(continued from previous page)

```
done = False

# Reset all of the variables
ob = env.reset() # Gets an observation as a response to resetting the variables
while True:
    # Get an observation, and input the previous reward, and indicator if the episode
    # is complete or not (done).
    action = agent.act(ob, reward, done)
    ob, reward, done, _ = env.step(action)
    if done:
        break
```

As such, the TradingEnvironment runs largely like this as well.

```
from tenstrade.environments import TradingEnvironment
from tenstrade.strategies import StableBaselinesTradingStrategy

environment = TradingEnvironment(exchange=exchange,
                                action_scheme=action_scheme,
                                reward_scheme=reward_scheme,
                                feature_pipeline=feature_pipeline)

strategy.environment = environment
test_performance = strategy.run(episodes=1, testing=True)
```

Here you may notice that we don't have the same training code we saw above:

```
while True:
    # Get an observation, and input the previous reward, and indicator if the episode
    # is complete or not (done).
    action = agent.act(ob, reward, done)
    ob, reward, done, _ = env.step(action)
    if done:
        break
```

That's because the code to run that exist directly inside of the TradingStrategy codebase. The command run, has abstractions of that code. Please refer to the Strategies codebase.

1.13.2 Functions:

To better understand what's inside of the TradingEnvironment, you should understand the notation. Everything that begins with an underscore _ is a relatively private function. While everything that doesn't have the underscore is a public facing function.

Private

- `_take_action`
 - Determines a specific trade to be taken and executes it within the exchange.
- `_next_observation`
 - Returns the next observation from the exchange.
- `_get_reward`

- Returns the reward for the current timestep.
- `_done`
 - Returns whether or not the environment is done and should be restarted. The two key conditions to determine if the environment is completed is if either 90% of the funds are lost or if there are no more observations left.
- `_info`
 - Returns any auxiliary, diagnostic, or debugging information for the current timestep.

Public

- `step`
 - Run one timestep within the environment based on the specified action.
- `reset`
 - Resets the state of the environment and returns an initial observation.
- `render`
 - This sends an output of what's occurring in the gym environment for the user to keep track of.

Almost 100% of the private functions belong in the `step` function.

1.14 Exchange

Exchanges determine the universe of tradable instruments within a trading environment, return observations to the environment on each time step, and execute trades made within the environment. There are two types of exchanges: live and simulated.

Live exchanges are implementations of `Exchange` backed by live pricing data and a live trade execution engine. For example, `CCXTExchange` is a live exchange, which is capable of returning pricing data and executing trades on hundreds of live cryptocurrency exchanges, such as `Binance` and `Coinbase`.

```
import ccxt
from tensortrade.exchanges.live import CCXTExchange

coinbase = ccxt.coinbasepro()
exchange = CCXTExchange(exchange=coinbase, base_instrument='USD')
```

There are also exchanges for stock and ETF trading, such as `RobinhoodExchange` and `InteractiveBrokersExchange`, but these are still works in progress.

Simulated exchanges, on the other hand, are implementations of `Exchange` backed by simulated pricing data and trade execution.

For example, `FBMExchange` is a simulated exchange, which generates pricing and volume data using fractional brownian motion (FBM). Since its price is simulated, the trades it executes must be simulated as well. The exchange uses a simple slippage model to simulate price and volume slippage on trades, though like almost everything in `TensorTrade`, this slippage model can easily be swapped out for something more complex.

```
from tensortrade.exchanges.simulated import FBMExchange

exchange = FBMExchange(base_instrument='BTC', timeframe='1h')
```

Though the `FBMExchange` generates fake price and volume data using a stochastic model, it is simply an implementation of `SimulatedExchange`. Under the hood, `SimulatedExchange` only requires a `data_frame` of price history to generate its simulations. This `data_frame` can either be provided by a coded implementation such as `FBMExchange`, or at runtime.

```
import pandas as pd
from tensortrade.exchanges.simulated import SimulatedExchange

df = pd.read_csv('./data/btc_ohclv_1h.csv')
exchange = SimulatedExchange(data_frame=df, base_instrument='USD')
```

1.14.1 Purpose of Exchange?

Inside of the [README](#), you'll have seen the reason why we have the higher level abstract. It reiterate, `Exchange` is the highest level abstract for all other exchanges. It has functions used through all others.

1.14.2 Class Parameters

- `base_instrument`
 - The exchange symbol of the instrument to store/measure value in.
- `dtype`
 - A type or str corresponding to the dtype of the `observation_space`.
- `feature_pipeline`
 - A pipeline of feature transformations for transforming observations.

1.14.3 Properties and Setters

- `base_instrument`
 - The exchange symbol of the instrument to store/measure value in.
- `dtype`
 - A type or str corresponding to the dtype of the `observation_space`.
- `feature_pipeline`
 - A pipeline of feature transformations for transforming observations.
- `base_precision`
 - The floating point precision of the base instrument.
- `instrument_precision`
 - The floating point precision of the instrument to be traded.
- `initial_balance`
 - The initial balance of the base symbol on the exchange.
- `balance`
 - The current balance of the base symbol on the exchange.
- `portfolio`

- The current balance of each symbol on the exchange (non-positive balances excluded).
- `trades`
 - A list of trades made on the exchange since the last reset.
- `performance`
 - The performance of the active account on the exchange since the last reset.
- `generated_space`
 - The initial shape of the observations generated by the exchange, before feature transformations.
- `observation_columns`
 - The list of column names of the observation data frame generated by the exchange, before feature transformations.
- `observation_space`
 - The final shape of the observations generated by the exchange, after feature transformations.
- `net_worth`
 - Calculate the net worth of the active account on the exchange.
- `profit_loss_percent`
 - Calculate the percentage change in net worth since the last reset.
- `has_next_observation`
 - If `False`, the exchange's data source has run out of observations.
 - Resetting the exchange may be necessary to continue generating observations.

1.14.4 Functions

Below are the functions that the `Exchange` uses to effectively operate.

Private

- `_create_observation_generator`

Public

- `has_next_observation`
 - Return the reward corresponding to the selected risk-adjusted return metric.
- `next_observation`
 - Generate the next observation from the exchange.
- `instrument_balance`
 - The current balance of the specified symbol on the exchange, denoted in the base instrument.
- `current_price`
 - The current price of an instrument on the exchange, denoted in the base instrument.
- `execute_trade`

- Execute a trade on the exchange, accounting for slippage.
- `reset`
 - Reset the feature pipeline, initial balance, trades, performance, and any other temporary stateful data.

1.14.5 Use Cases

...

1.15 SimulatedExchange

An exchange, in which the price history is based off the supplied data frame and trade execution is largely decided by the designated slippage model. If the `data_frame` parameter is not supplied upon initialization, it must be set before the exchange can be used within a trading environment.

The reason we create simulated exchanges is so we create more robust models quickly. We train using either sampled or fake information. Usually the data sets are stochastic in nature.

1.15.1 Class Parameters

- `base_instrument`
 - The exchange symbol of the instrument to store/measure value in.
- `dtype`
 - A type or str corresponding to the dtype of the `observation_space`.
- `feature_pipeline`
 - A pipeline of feature transformations for transforming observations.
- `kwargs`
 - Go through each of them here

1.15.2 Properties and Setters

- `base_instrument`
 - The exchange symbol of the instrument to store/measure value in.
- `dtype`
 - A type or str corresponding to the dtype of the `observation_space`.
- `feature_pipeline`
 - A pipeline of feature transformations for transforming observations.
- `base_precision`
 - The floating point precision of the base instrument.
- `instrument_precision`
 - The floating point precision of the instrument to be traded.
- `initial_balance`

- The initial balance of the base symbol on the exchange.
- `balance`
 - The current balance of the base symbol on the exchange.
- `portfolio`
 - The current balance of each symbol on the exchange (non-positive balances excluded).
- `trades`
 - A list of trades made on the exchange since the last reset.
- `performance`
 - The performance of the active account on the exchange since the last reset.
- `generated_space`
 - The initial shape of the observations generated by the exchange, before feature transformations.
- `observation_columns`
 - The list of column names of the observation data frame generated by the exchange, before feature transformations.
- `observation_space`
 - The final shape of the observations generated by the exchange, after feature transformations.
- `net_worth`
 - Calculate the net worth of the active account on the exchange.
- `profit_loss_percent`
 - Calculate the percentage change in net worth since the last reset.
- `has_next_observation`
 - If `False`, the exchange’s data source has run out of observations.
 - Resetting the exchange may be necessary to continue generating observations.

1.15.3 Functions

Below are the functions that the `SimulatedExchange` uses to effectively operate.

Private

- `_create_observation_generator`

Public

- `has_next_observation`
 - Return the reward corresponding to the selected risk-adjusted return metric.
- `next_observation`
 - Generate the next observation from the exchange.
- `instrument_balance`

- The current balance of the specified symbol on the exchange, denoted in the base instrument.
- `current_price`
 - The current price of an instrument on the exchange, denoted in the base instrument.
- `execute_trade`
 - Execute a trade on the exchange, accounting for slippage.
- `reset`
 - Reset the feature pipeline, initial balance, trades, performance, and any other temporary stateful data.

1.15.4 Use Cases

```
import pandas as pd
from tensortrade.exchanges.simulated import SimulatedExchange

df = pd.read_csv('./data/btc_ohclv_1h.csv')
exchange = SimulatedExchange(data_frame=df, base_instrument='USD')
```

1.15.5 Use Cases

Working on it.

1.16 FBMExchange

Fractal Brownian Motion

A simulated exchange, in which the price history is based off a fractional brownian motion model with supplied parameters.

1.16.1 What is Fractal Brownian Motion?

Fractal Brownian Motion is apart of a class of differential equations called stochastic processes.

Stochastic processes are an accumulation of random variables that help us describe the emergence of a system over time. The power of them is that they can be used to describe all of the world around us. In fact, during early 1900 one of the first active uses of Stochastic Processes was with valuing stock options. It was called a Brownian Motion, developed by a French mathematician named Louis Bachelier. It can also be used for looking at random interactions of molecules over time. We use this method to solve reinforcement learning's sample inefficiency problem.

.

We generate prices, and train on that. Simple.

1.16.2 Class Parameters

- `base_instrument`
 - The exchange symbol of the instrument to store/measure value in.

- `dtype`
 - A type or str corresponding to the dtype of the `observation_space`.
- `feature_pipeline`
 - A pipeline of feature transformations for transforming observations.

1.16.3 Properties and Setters

- `base_instrument`
 - The exchange symbol of the instrument to store/measure value in.
- `dtype`
 - A type or str corresponding to the dtype of the `observation_space`.
- `feature_pipeline`
 - A pipeline of feature transformations for transforming observations.
- `base_precision`
 - The floating point precision of the base instrument.
- `instrument_precision`
 - The floating point precision of the instrument to be traded.
- `initial_balance`
 - The initial balance of the base symbol on the exchange.
- `balance`
 - The current balance of the base symbol on the exchange.
- `portfolio`
 - The current balance of each symbol on the exchange (non-positive balances excluded).
- `trades`
 - A list of trades made on the exchange since the last reset.
- `performance`
 - The performance of the active account on the exchange since the last reset.
- `generated_space`
 - The initial shape of the observations generated by the exchange, before feature transformations.
- `observation_columns`
 - The list of column names of the observation data frame generated by the exchange, before feature transformations.
- `observation_space`
 - The final shape of the observations generated by the exchange, after feature transformations.
- `net_worth`
 - Calculate the net worth of the active account on the exchange.
- `profit_loss_percent`

- Calculate the percentage change in net worth since the last reset.
- `has_next_observation`
 - If `False`, the exchange’s data source has run out of observations.
 - Resetting the exchange may be necessary to continue generating observations.

1.16.4 Functions

Below are the functions that the `FBMExchange` uses to effectively operate.

Private

- `_create_observation_generator`

Public

- `has_next_observation`
 - Return the reward corresponding to the selected risk-adjusted return metric.
- `next_observation`
 - Generate the next observation from the exchange.
- `instrument_balance`
 - The current balance of the specified symbol on the exchange, denoted in the base instrument.
- `current_price`
 - The current price of an instrument on the exchange, denoted in the base instrument.
- `execute_trade`
 - Execute a trade on the exchange, accounting for slippage.
- `reset`
 - Reset the feature pipeline, initial balance, trades, performance, and any other temporary stateful data.

1.16.5 Use Cases

Use Case #1: Generate Price History for Exchange

We generate the price history when

```
from tensortrade.exchanges.simulated import FBMExchange

exchange = FBMExchange(base_instrument='BTC', timeframe='1h')
```

1.17 CCXTExchange

An exchange for trading on CCXT-supported cryptocurrency exchanges.

1.17.1 Class Parameters

- `base_instrument`
 - The exchange symbol of the instrument to store/measure value in.
- `dtype`
 - A type or str corresponding to the dtype of the `observation_space`.
- `feature_pipeline`
 - A pipeline of feature transformations for transforming observations.

1.17.2 Properties and Setters

- `base_instrument`
 - The exchange symbol of the instrument to store/measure value in.
- `dtype`
 - A type or str corresponding to the dtype of the `observation_space`.
- `feature_pipeline`
 - A pipeline of feature transformations for transforming observations.
- `base_precision`
 - The floating point precision of the base instrument.
- `instrument_precision`
 - The floating point precision of the instrument to be traded.
- `initial_balance`
 - The initial balance of the base symbol on the exchange.
- `balance`
 - The current balance of the base symbol on the exchange.
- `portfolio`
 - The current balance of each symbol on the exchange (non-positive balances excluded).
- `trades`
 - A list of trades made on the exchange since the last reset.
- `performance`
 - The performance of the active account on the exchange since the last reset.
- `generated_space`
 - The initial shape of the observations generated by the exchange, before feature transformations.
- `observation_columns`
 - The list of column names of the observation data frame generated by the exchange, before feature transformations.
- `observation_space`
 - The final shape of the observations generated by the exchange, after feature transformations.

- `net_worth`
 - Calculate the net worth of the active account on the exchange.
- `profit_loss_percent`
 - Calculate the percentage change in net worth since the last reset.
- `has_next_observation`
 - If `False`, the exchange’s data source has run out of observations.
 - Resetting the exchange may be necessary to continue generating observations.

1.17.3 Functions

Below are the functions that the `Exchange` uses to effectively operate.

Private

- `_create_observation_generator`

Public

- `has_next_observation`
 - Return the reward corresponding to the selected risk-adjusted return metric.
- `next_observation`
 - Generate the next observation from the exchange.
- `instrument_balance`
 - The current balance of the specified symbol on the exchange, denoted in the base instrument.
- `current_price`
 - The current price of an instrument on the exchange, denoted in the base instrument.
- `execute_trade`
 - Execute a trade on the exchange, accounting for slippage.
- `reset`
 - Reset the feature pipeline, initial balance, trades, performance, and any other temporary stateful data.

1.17.4 Use Cases

Use Case #1: Initiating `CCXTExchange`

```
import ccxt
from tensortrade.exchanges.live import CCXTExchange

coinbase = ccxt.coinbasepro()
exchange = CCXTExchange(exchange=coinbase, base_instrument='USD')
```

1.18 InteractiveBrokersExchange

An exchange for trading using the Interactive Brokers API.

1.18.1 Class Parameters

- `base_instrument`
 - The exchange symbol of the instrument to store/measure value in.
- `dtype`
 - A type or str corresponding to the dtype of the `observation_space`.
- `feature_pipeline`
 - A pipeline of feature transformations for transforming observations.

1.18.2 Properties and Setters

- `base_instrument`
 - The exchange symbol of the instrument to store/measure value in.
- `dtype`
 - A type or str corresponding to the dtype of the `observation_space`.
- `feature_pipeline`
 - A pipeline of feature transformations for transforming observations.
- `base_precision`
 - The floating point precision of the base instrument.
- `instrument_precision`
 - The floating point precision of the instrument to be traded.
- `initial_balance`
 - The initial balance of the base symbol on the exchange.
- `balance`
 - The current balance of the base symbol on the exchange.
- `portfolio`
 - The current balance of each symbol on the exchange (non-positive balances excluded).
- `trades`
 - A list of trades made on the exchange since the last reset.
- `performance`
 - The performance of the active account on the exchange since the last reset.
- `generated_space`
 - The initial shape of the observations generated by the exchange, before feature transformations.
- `observation_columns`

- The list of column names of the observation data frame generated by the exchange, before feature transformations.
- `observation_space`
 - The final shape of the observations generated by the exchange, after feature transformations.
- `net_worth`
 - Calculate the net worth of the active account on the exchange.
- `profit_loss_percent`
 - Calculate the percentage change in net worth since the last reset.
- `has_next_observation`
 - If `False`, the exchange’s data source has run out of observations.
 - Resetting the exchange may be necessary to continue generating observations.

1.18.3 Functions

Below are the functions that the `Exchange` uses to effectively operate.

Private

- `_create_observation_generator`
 - ...

Public

- `has_next_observation`
 - Return the reward corresponding to the selected risk-adjusted return metric.
- `next_observation`
 - Generate the next observation from the exchange.
- `instrument_balance`
 - The current balance of the specified symbol on the exchange, denoted in the base instrument.
- `current_price`
 - The current price of an instrument on the exchange, denoted in the base instrument.
- `execute_trade`
 - Execute a trade on the exchange, accounting for slippage.
- `reset`
 - Reset the feature pipeline, initial balance, trades, performance, and any other temporary stateful data.

1.18.4 Use Cases

Use Case #1: Initiating Interactive Broker

We generate the price history when

```
from tenstrade.exchanges.live import InteractiveBrokersExchange

exchange = InteractiveBrokersExchange(base_instrument='BTC', timeframe='1h')
```

1.19 FeaturePipeline

Feature pipelines are meant for transforming observations from the environment into meaningful features for an agent to learn from. If a pipeline has been added to a particular exchange, then observations will be passed through the `FeaturePipeline` before being output to the environment.

For example, a feature pipeline could normalize all price values, make a time series stationary, add a moving average column, and remove an unnecessary column, all before the observation is returned to the agent.

Feature pipelines can be initialized with an arbitrary number of comma-separated transformers. Each `FeatureTransformer` needs to be initialized with the set of columns to transform, or if nothing is passed, all input columns will be transformed.

Each feature transformer has a `transform` method, which will transform a single observation (a `pandas.DataFrame`) from a larger data set, keeping any necessary state in memory to transform the next frame. For this reason, it is often necessary to reset the `FeatureTransformer` periodically. This is done automatically each time the parent `FeaturePipeline` or `Exchange` is reset.

1.19.1 How It Operates

The `FeaturePipeline` has a setup that resembles the `keras` library. The concept is simple:

1. We take in an observation of data (price information), usually in the form of a `pandas` dataframe.
2. We take the observation and effectively run it through all declared ways of transforming that data inside of the `FeaturePipeline` and turn the result as a `gym.space`.

Just like `keras`'s `Sequential` module, it accepts a list inside of its constructor and iterates through each piece on call. To draw on parallels, look at `keras`:

```
model = Sequential([
    Dense(32, input_shape=(500,)),
    Dense(32)
])
```

1.19.2 Class Parameters

- `steps`
 - A list of feature transformations to apply to observations.
- `dtype`
 - The `dtype` elements in the pipeline should be cast to.

1.19.3 Properties and Setters

- steps
 - A list of feature transformations to apply to observations.
- dtype
 - The dtype that elements in the pipeline should be input and output as.
- reset
 - Reset all transformers within the feature pipeline.

1.19.4 Functions

Below are the functions that the `FeaturePipeline` uses to effectively operate.

Private

- `_transform`
 - Utility method for transforming observations via a list of *make changes here* `FeatureTransformer` objects.
 - In other words, it runs through all of the steps in a for loop, and casts the response.

The code from the transform function: As you see, it iterates through every step and adds the observation to the dataframe.

```
for transformer in self._steps:
    observations = transformer.transform(observations)
```

At the end the observations are converted into a ndarray so that they can be interpreted by the agent.

Public

- reset
 - Reset all transformers within the feature pipeline.
- transform
 - Apply the pipeline of feature transformations to an observation frame.

1.19.5 Use Cases

Use Case #1: Initiate Pipeline

```
from tensortrade.features import FeaturePipeline
from tensortrade.features.scalers import MinMaxNormalizer
from tensortrade.features.stationarity import FractionalDifference
from tensortrade.features.indicators import SimpleMovingAverage

price_columns = ["open", "high", "low", "close"]
normalize_price = MinMaxNormalizer(price_columns)
moving_averages = SimpleMovingAverage(price_columns)
```

(continues on next page)

(continued from previous page)

```
difference_all = FractionalDifference(difference_order=0.6)
feature_pipeline = FeaturePipeline(steps=[normalize_price,
                                         moving_averages,
                                         difference_all])

exchange.feature_pipeline = feature_pipeline
```

1.20 FeatureTransformer

As stated before in the [overview](#), We use an ABCMeta abstract hierarchy to handle the transformation calls of each asset. The `FeatureTransformer` is an abstract of all other price transformers available inside of the `tensortrade` library. As such, it has a set of common functions that are called on almost every transformer.

1.20.1 Properties and Setters

- `columns`
 - A list of column names to normalize

1.20.2 Functions

Below are the functions that the `FeatureTransformer` uses to effectively operate.

Private

None

Public

- `reset`
 - Optionally implementable method for resetting stateful transformers.
- `transform`
 - Transform the data set and return a new data frame.

1.21 MinMaxNormalizer

A transformer for normalizing values within a feature pipeline by the column-wise extrema.

1.21.1 Class Parameters

- `columns`
 - A list of column names to normalize.
- `feature_min`

- The minimum value in the range to scale to.
- `feature_max`
 - The maximum value in the range to scale to.
- `inplace`
 - If `False`, a new column will be added to the output for each input column.

1.21.2 Properties and Setters

None

1.21.3 Functions

Below are the functions that the `MinMaxNormalizer` uses to effectively operate.

Private

None

Public

- `transform`
 - Apply the pipeline of feature transformations to an observation frame.

1.21.4 Use Cases:

```
from tensortrade.features import FeaturePipeline
from tensortrade.features.scalers import MinMaxNormalizer
from tensortrade.features.stationarity import FractionalDifference
from tensortrade.features.indicators import SimpleMovingAverage
price_columns = ["open", "high", "low", "close"]
normalize_price = MinMaxNormalizer(price_columns)
moving_averages = SimpleMovingAverage(price_columns)
difference_all = FractionalDifference(difference_order=0.6)
feature_pipeline = FeaturePipeline(steps=[normalize_price,
                                         moving_averages,
                                         difference_all])
exchange.feature_pipeline = feature_pipeline
```

1.22 StandardNormalizer

A transformer for normalizing values within a feature pipeline by removing the mean and scaling to unit variance.

1.22.1 Class Parameters

- `columns`
 - A list of column names to normalize.
- `feature_min`
 - The minimum value in the range to scale to.
- `feature_max`
 - The maximum value in the range to scale to.
- `inplace`
 - If `False`, a new column will be added to the output for each input column.

1.22.2 Properties and Setters

- `None`

1.22.3 Functions

Below are the functions that the `StandardNormalizer` uses to effectively operate.

Private

None

Public

- `transform`
 - Apply the pipeline of feature transformations to an observation frame.
- `reset`
 - Resets the history of the standard scaler.

1.22.4 Use Cases:

Use Case #1: Different Input Spaces

This `StandardNormalizer` operates differently depending on if we pretransform the observation to an `ndarray` or keep it as a `pandas dataframe`.

```
from tenstrade.features import FeaturePipeline
from tenstrade.features.scalers import StandardNormalizer
from tenstrade.features.stationarity import FractionalDifference
from tenstrade.features.indicators import SimpleMovingAverage
price_columns = ["open", "high", "low", "close"]
normalize_price = MinMaxNormalizer(price_columns)
moving_averages = SimpleMovingAverage(price_columns)
difference_all = FractionalDifference(difference_order=0.6)
```

(continues on next page)

(continued from previous page)

```
feature_pipeline = FeaturePipeline(steps=[normalize_price,
                                         moving_averages,
                                         difference_all])
exchange.feature_pipeline = feature_pipeline
```

1.23 FractionalDifference

A transformer for differencing values within a feature pipeline by a fractional order. It removes the stationarity of the dataset available in realtime. To learn more about why non-stationarity should be converted to stationary information, please look at the blog [here](#).

1.23.1 Class Parameters

- `columns`
 - A list of column names to difference.
- `difference_order`
 - The fractional difference order. Defaults to 0.5.
- `difference_threshold`
 - A type or str corresponding to the dtype of the `observation_space`.
- `inplace`
 - If `False`, a new column will be added to the output for each input column.

1.23.2 Functions

Below are the functions that the `FractionalDifference` uses to effectively operate.

Private

- `_difference_weights`
 - Gets the weights for ...
- `_fractional_difference`
 - Computes fractionally differenced series, with an increasing window width.

Public

- `transform`
 - Apply the pipeline of feature transformations to an observation frame.
- `reset`
 - Resets the history of the standard scaler.

1.23.3 Use Cases:

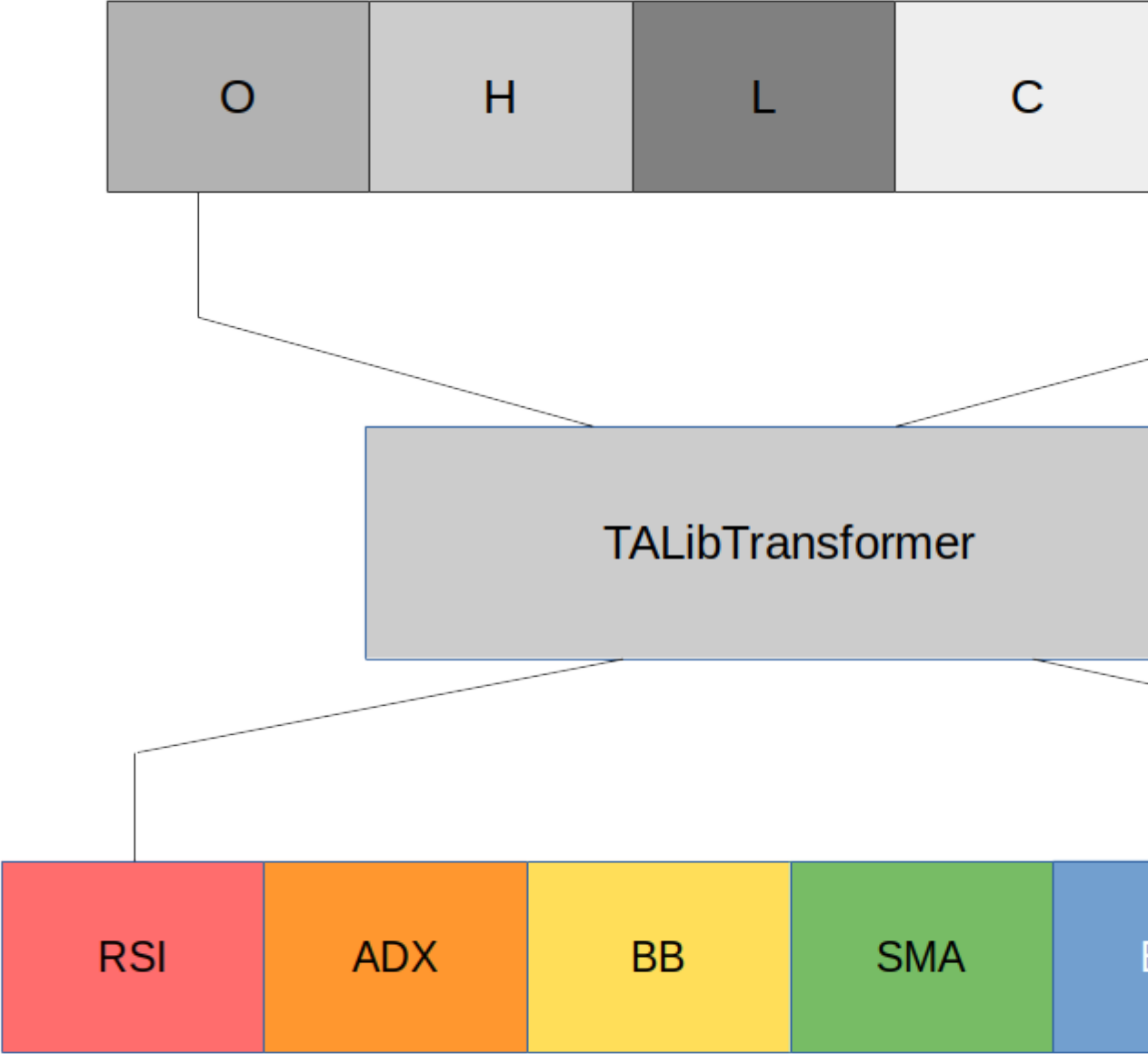
Use Case #1: Different Input Spaces

This `FeatureTransformer` operates differently depending on if we pretransform the observation to an `ndarray` or keep it as a `pandas dataframe`.

```
from tenstrade.features import FeaturePipeline
from tenstrade.features.stationarity import FractionalDifference
price_columns = ["open", "high", "low", "close"]
difference_all = FractionalDifference(difference_order=0.6) # fractional difference_
↪ is seen here
feature_pipeline = FeaturePipeline(steps=[difference_all])
exchange.feature_pipeline = feature_pipeline
```

1.24 TALibIndicator

Adds one or more TALib indicators to a data frame, based on existing open, high, low, and close column values.



1.24.1 Class Parameters

- `indicators`
 - A list of indicators you want to transform the price information to.
- `lows`
 - The lower end of the observation space. See `spaces.Box` to best understand.
- `highs`
 - The lower end of the observation space. See `spaces.Box` to best understand.

1.24.2 Properties and Setters

- `NONE`

1.24.3 Functions

Below are the functions that the `TALibIndicator` uses to effectively operate.

Private

- `_str_to_indicator` - Converts the name of an indicator to an actual instance of the indicator. For a list of indicators see list [here](#).

Public

- `transform`
 - Transform the data set and return a new data frame.

1.24.4 Use Cases:

1.24.5 Use Cases

Use Case #1: Selecting Indicators

The key advantage the `TALibIndicator` has is that it allows us to dynamically set indicators according what's inside of a list. For instance, if we're trying to get the RSI and EMA together, we would run the following parameters inside of the indicator.

```
talib_indicator = TALibIndicator(["rsi", "ema"])
```

This runs through the indicators in the list, at runtime and matches them to what is seen inside of TA-Lib. The features are then flattened into the `output_space`, both into the high and low segment of `space.Box`.

```
for i in range(len(self._indicators)):
    output_space.low = np.append(output_space.low, self._lows[i])
    output_space.high = np.append(output_space.high, self._highs[i])
```

Actual Use

```
from tenstrade.features import FeaturePipeline
from tenstrade.features.scalars import MinMaxNormalizer
from tenstrade.features.stationarity import FractionalDifference
from tenstrade.features.indicators import TalibIndicator
price_columns = ["open", "high", "low", "close"]
normalize_price = MinMaxNormalizer(price_columns)
moving_averages = TalibIndicator(["EMA", "RSI", "BB"])
difference_all = FractionalDifference(difference_order=0.6)
feature_pipeline = FeaturePipeline(steps=[normalize_price,
                                         moving_averages,
                                         difference_all])
exchange.feature_pipeline = feature_pipeline
```

1.25 ActionScheme

Action schemes define the action space of the environment and convert an agent's actions into executable trades.

For example, if we were using a discrete action space of 3 actions (0 = hold, 1 = buy 100 %, 2 = sell 100%), our learning agent does not need to know that returning an action of 1 is equivalent to buying an instrument. Rather, our agent needs to know the reward for returning an action of 1 in specific circumstances, and can leave the implementation details of converting actions to trades to the `ActionScheme`.

Each action scheme has a `get_trade` method, which will transform the agent's specified action into an executable `Trade`. It is often necessary to store additional state within the scheme, for example to keep track of the currently traded position. This state should be reset each time the action scheme's `reset` method is called, which is done automatically when the parent `TradingEnvironment` is reset.

1.25.1 What is an Action?

This is a review of what was mentioned inside of the overview section. It explains how a RL operates. You'll better understand what an action is in context of an observation space and reward. At the same time, hopefully this will be a proper refresher.

An action is a predefined value of how the machine should move inside of the world. To better summarize, its a *command that a player would give inside of a video game in respose to a stimuli*. The commands usually come in the form of an `action_space`. An `action_space` is something that represents how to make the user move inside of an environment. While it might not be easily interpretable by humans, it can easily be interpreted by a machine.

Let's look at a good example. Lets say we're trying to balance a cart with a pole on it (cartpole). We can choose to move the cart left and right. This is a `Discrete(2)` action type.

- 0 - Push cart to the left
- 1 - Push cart to the right

When we get the action from the RL agent, the environment will see that number instead of a name. We can create lists, tuples, and a box.

1.25.2 Setters & Properties

Each property and property setter.

- dtype

- A type or str corresponding to the dtype of the `action_space`.
- `exchange`
 - The exchange being used by the current trading environment.
 - This will be set by the trading environment upon initialization. Setting the exchange causes the scheme to reset.
- `action_space`
 - The shape of the actions produced by the scheme. This takes in a `gym.space` and is different for each given scheme.

1.25.3 Functions

- `reset`
 - Optionally implementable method for resetting stateful schemes.
- `get_trade`
 - Get the trade to be executed on the exchange based on the action provided.
 - Usually this is the way we distill the information generated from the `action_space`.

1.26 ContinuousActions

Simple continuous scheme, which calculates the trade size as a fraction of the total balance.

1.26.1 Key Variables

- `max_allowed_slippage`
 - The exchange symbols of the instruments being traded.
- `instrument`
 - The number of bins to divide the total balance by. Defaults to 20 (i.e. $1/20, 2/20, \dots, 20/20$).
- `instrument`
 - The maximum size above the current price the scheme will pay for an instrument. Defaults to 1.0 (i.e. 1%).

1.26.2 Setters & Properties

Each property and property setter.

- `dtype`
 - A type or str corresponding to the dtype of the `action_space`.
- `exchange`
 - The exchange being used by the current trading environment.
 - This will be set by the trading environment upon initialization. Setting the exchange causes the scheme to reset.

- `action_space`
 - The shape of the actions produced by the scheme. This takes in a `gym.space` and is different for each given scheme.

1.26.3 Functions

- `reset`
 - Optionally implementable method for resetting stateful schemes.
- `get_trade`
 - Get the trade to be executed on the exchange based on the action provided.
 - Usually this is the way we distill the information generated from the `action_space`.

1.26.4 Use Cases

TODO: Place Use Case Here

1.27 DiscreteActions

Simple discrete scheme, which calculates the trade size as a fraction of the total balance.

1.27.1 Key Variables

- `instruments`
 - The exchange symbols of the instruments being traded.
- `actions_per_instrument`
 - The number of bins to divide the total balance by. Defaults to 20 (i.e. 1/20, 2/20, ..., 20/20).
- `max_allowed_slippage_percent`
 - The maximum size above the current price the scheme will pay for an instrument. Defaults to 1.0 (i.e. 1%).

1.27.2 Setters & Properties

Each property and property setter.

- `dtype`
 - A type or str corresponding to the dtype of the `action_space`.
- `exchange`
 - The exchange being used by the current trading environment.
 - This will be set by the trading environment upon initialization. Setting the exchange causes the scheme to reset.
- `action_space`

- The shape of the actions produced by the scheme. This takes in a `gym.Space` and is different for each given scheme.

1.27.3 Functions

- `reset`
 - Optionally implementable method for resetting stateful schemes.
- `get_trade`
 - Get the trade to be executed on the exchange based on the action provided.
 - Usually this is the way we distill the information generated from the `action_space`.

1.27.4 Use Cases

```
from tensortrade.actions import DiscreteActions

action_scheme = DiscreteActions(n_actions=20, instrument='BTC')
```

This discrete action scheme uses 20 discrete actions, which equates to 4 discrete sizes for each of the 5 trade types (market buy/sell, limit buy/sell, and hold). E.g. [0,5,10,15]=hold, 1=market buy 25%, 2=market sell 25%, 3=limit buy 25%, 4=limit sell 25%, 6=market buy 50%, 7=market sell 50%, etc...

1.28 MultiDiscreteActions

Discrete scheme, which calculates the trade size as a fraction of the total balance for each instrument provided.

The trade type is determined by `action % len(TradeType)`, and the trade size is determined by the multiplicity of the action. For example, 0 = HOLD, 1 = LIMIT_BUY|0.25, 2 = MARKET_BUY|0.25, 5 = HOLD, 6 = LIMIT_BUY|0.5, 7 = MARKET_BUY|0.5, etc.

1.28.1 Key Variables

- `_instruments`
 - The exchange symbols of the instruments being traded.
- `_actions_per_instrument`
 - The number of bins to divide the total balance by. Defaults to 20 (i.e. 1/20, 2/20, ..., 20/20).
- `_max_allowed_slippage_percent`
 - The maximum size above the current price the scheme will pay for an instrument. Defaults to 1.0 (i.e. 1%).

1.28.2 Setters & Properties

Each property and property setter.

- `dtype`
 - A type or str corresponding to the dtype of the `action_space`.

- `exchange`
 - The exchange being used by the current trading environment.
 - This will be set by the trading environment upon initialization. Setting the exchange causes the scheme to reset.
- `action_space`
 - The shape of the actions produced by the scheme. This takes in a `gym.space` and is different for each given scheme.

1.28.3 Functions

- `reset`
 - Optionally implementable method for resetting stateful schemes.
- `get_trade`
 - Get the trade to be executed on the exchange based on the action provided.
 - Usually this is the way we distill the information generated from the `action_space`.

1.28.4 Use Cases

```
from tensortrade.actions import MultiDiscreteActions

action_scheme = MultiDiscreteActions(n_actions=20, instrument='BTC')
```

This discrete action scheme uses 20 discrete actions, which equates to 4 discrete sizes for each of the 5 trade types (market buy/sell, limit buy/sell, and hold). E.g. [0,5,10,15]=hold, 1=market buy 25%, 2=market sell 25%, 3=limit buy 25%, 4=limit sell 25%, 6=market buy 50%, 7=market sell 50%, etc...

1.29 Reward Scheme

Reward schemes receive the `Trade` taken at each time step and return a `float`, corresponding to the benefit of that specific action. For example, if the action taken this step was a sell that resulted in positive profits, our `RewardScheme` could return a positive number to encourage more trades like this. On the other hand, if the action was a sell that resulted in a loss, the scheme could return a negative reward to teach the agent not to make similar actions in the future.

A version of this example algorithm is implemented in `SimpleProfit`, however more complex schemes can obviously be used instead.

Each reward scheme has a `get_reward` method, which takes in the trade executed at each time step and returns a `float` corresponding to the value of that action. As with action schemes, it is often necessary to store additional state within a reward scheme for various reasons. This state should be reset each time the reward scheme's `reset` method is called, which is done automatically when the parent `TradingEnvironment` is reset.

Ultimately the agent creates a sequence of actions to maximize its total reward over a given time. The `RewardScheme` is an abstract class that encapsulates how to tell the trading bot in `tensortrade` if it's trading positively or negatively over time. The same methods will be called each time for each step, and we can directly swap out schemes.

1.29.1 Properties and Setters

- `exchange`
 - The central exchange for the scheme.
 - The exchange being used by the current trading environment. Setting the exchange causes the scheme to reset.

1.29.2 Methods

- `get_reward`
 - Gets the reward for the RL agent.
 - Returns a float corresponding to the benefit earned by the action taken this timestep.
- `reset`
 - Resets the current state if the reward has a state.
 - Optionally implementable method for resetting stateful schemes.

1.30 Risk Adjusted Returns

A reward scheme that rewards the agent for increasing its net worth, while penalizing more volatile strategies.

1.30.1 What are risk adjusted models?

When trading you often are not just looking at the overall returns of your model. You're also looking at the overall volatility of your trading strategy over time compared to other metrics. The two major strategies here are the sharpe and sortino ratio.

The **sharpe ratio** looks at the overall movements of the portfolio and generates a penalty for massive movements through a lower score. This includes major movements towards the upside and downside.

$$S = \left(\frac{R_p - R_f}{\sigma_p} \right)$$

The **sortino ratio** takes the same idea, though it focuses more on penalizing only the upside. That means it'll give a huge score for moments when the price moves upward, and will only give a negative score when the price drops heavily. This is a great direction for the RL algorithm. Seeing that we don't want to incur heavy downsides, yet want to take on large upsides, using this metric alone gives us lots of progress to mitigate downsides and increase upsides.

$$S = \frac{(R - MAR)}{\text{downside deviation}}$$

1.30.2 Class Parameters

- `return_algorithm`
 - The risk-adjusted return metric to use. Options are ‘sharpe’ and ‘sortino’. Defaults to ‘sharpe’.
- `risk_free_rate`
 - The risk free rate of returns to use for calculating metrics. Defaults to 0.
- `target_returns`
 - The target returns per period for use in calculating the sortino ratio. Default to 0.

1.30.3 Functions

Below are the functions that the `RiskAdjustedReturns` uses to effectively operate.

Private

- `_return_algorithm_from_str`
 - Allows us to dynamically choose an algorithm for the reward within a given selection. We can choose between either sharpe or sortino ratios. Each are volatility models we’ve discussed above.
- `_sharpe_ratio`
 - Return the sharpe ratio for a given series of a returns.
- `_sortino_ratio`
 - Return the sortino ratio for a given series of a returns.

Public

- `get_reward`
 - Return the reward corresponding to the selected risk-adjusted return metric.

1.30.4 Use Cases

...

1.31 Simple Profit

A reward scheme that rewards the agent for profitable trades and prioritizes trading over not trading.

1.31.1 Class Parameters

None

1.31.2 Functions

Below are the functions that the `SimpleProfit` uses to effectively operate.

1.31.3 Private

None

1.31.4 Public

- `reset` - Reset variables
 - Necessary to reset the last purchase price and state of open positions
 - Variables it resets
 - * `_purchase_price`
 - * The price the bot purchased the asset
 - * `_is_holding_instrument` - A boolean that shares with the `get_reward` function if we're currently holding onto a trade.
- `get_reward`
 - Returns the reward for the given action
 - The $5^{(\log_{10}(\text{profit}))}$ function simply slows the growth of the reward as trades get large.

1.31.5 Use Cases

The simple profit scheme needs to keep a history of profit over time. The way it does this is through looking at the portfolio as a means of keeping track of how the portfolio moves. It also keeps track to see if it's holding onto a trade as well. This is seen inside of the `get_reward` function.

Use Case #1: Buying

When the bot says buy, it sets the variable `_is_holding_instrument` to `True`, and sets the current price to the price of the trade.

We see that inside of this line of code here. This allows us to check to see if we've made a profit later.

```
elif trade.is_buy and trade.size > 0:
    self._purchase_price = trade.price
    self._is_holding_instrument = True
```

Use Case #2: Selling

We then sell afterward using the original trade price as a reference. Which is suggested in the lines below:

```
if trade.is_sell and trade.size > 0:
    self._is_holding_instrument = False
    profit_per_instrument = trade.price - self._purchase_price
    profit = trade.size * profit_per_instrument
    profit_sign = np.sign(profit)

    return profit_sign * (1 + (5 ** np.log10(abs(profit))))
```

1.32 Learning Agents

This is where the “deep” part of the deep reinforcement learning framework come in. Learning agents are where the math (read: magic) happens.

At each time step, the agent takes the observation from the environment as input, runs it through its underlying model (a neural network most of the time), and outputs the action to take. For example, the observation might be the previous open, high, low, and close price from the exchange. The learning model would take these values as input and output a value corresponding to the action to take, such as buy, sell, or hold.

It is important to remember the learning model has no intuition of the prices or trades being represented by these values. Rather, the model is simply learning which values to output for specific input values or sequences of input values, to earn the highest reward.

1.33 Stable Baselines

In this example, we will be using the Stable Baselines library to provide learning agents to our trading scheme, however, the TensorTrade framework is compatible with many reinforcement learning libraries such as Tensorforce, Ray’s RLLib, OpenAI’s Baselines, Intel’s Coach, or anything from the TensorFlow line such as TF Agents.

It is possible that custom TensorTrade learning agents will be added to this framework in the future, though it will always be a goal of the framework to be interoperable with as many existing reinforcement learning libraries as possible, since there is so much concurrent growth in the space. But for now, Stable Baselines is simple and powerful enough for our needs.

```
from stable_baselines.common.policies import MlpLnLstmPolicy
from stable_baselines import PPO2

model = PPO2
policy = MlpLnLstmPolicy
params = { "learning_rate": 1e-5 }

agent = model(policy, environment, model_kwargs=params)
```

Note: Stable Baselines is not required to use TensorTrade though it is required for this tutorial. This example uses a GPU-enabled Proximal Policy Optimization model with a layer-normalized LSTM perceptron network. If you would like to know more about Stable Baselines, you can view the [Documentation](#).

1.34 Tensorforce

I will also quickly cover the Tensorforce library to show how simple it is to switch between reinforcement learning frameworks.

```
from tensorforce.agents import Agent

agent_spec = {
    "type": "ppo_agent",
    "step_optimizer": {
        "type": "adam",
        "learning_rate": 1e-4
    },
    "discount": 0.99,
    "likelihood_ratio_clipping": 0.2,
}

network_spec = [
    dict(type='dense', size=64, activation="tanh"),
    dict(type='dense', size=32, activation="tanh")
]

agent = Agent.from_spec(spec=agent_spec,
                        kwargs=dict(network=network_spec,
                                    states=environment.states,
                                    actions=environment.actions))
```

If you would like to know more about Tensorforce agents, you can view the [Documentation](#).

1.35 TradingStrategy

A `TradingStrategy` consists of a learning agent and one or more trading environments to tune, train, and evaluate on. If only one environment is provided, it will be used for tuning, training, and evaluating. Otherwise, a separate environment may be provided at each step.

1.36 StableBaselinesTradingStrategy

A trading strategy capable of self tuning, training, and evaluating with stable-baselines.

1.36.1 Class Parameters

- `environment`
 - A `TradingEnvironment` instance for the agent to trade within.
- `agent`
 - A Tensorforce agent or agent specification.
- `model`
 - The runner will automatically save the best agent
- `policy`

- The RL policy to train the agent’s model with. Defaults to ‘MlpPolicy’.
- `_model_kwargs`
 - ...

1.36.2 Properties and Setters

- `agent`
 - A `TradingEnvironment` instance for the agent to trade within.
- `max_episode_timesteps`
 - The maximum timesteps per episode.

1.36.3 Functions

- `restore_agent`
 - Deserialize the strategy’s learning agent from a file.
 - **parameters:**
 - * `path`
 - The `str` path of the file the agent specification is stored in.
- `save_agent`
 - Serialize the learning agent to a file for restoring later.
 - **parameters:**
 - * `path`
 - The `str` path of the file to store the agent specification in.
- `tune`
 - Function `NotImplemented`
- `run`
 - Runs all of the episodes specified.
 - **parameters:**
 - * `steps`
 - * `episodes`
 - * `episode_callback`
 - * `evaluation`

1.36.4 Use Cases

Use Case #1: Run a Strategy

```
from stable_baselines import PPO2
from tensortrade.strategies import StableBaselinesTradingStrategy
from tensortrade.environments import TradingEnvironment

environment = TradingEnvironment(exchange=exchange,
                                action_strategy=action_strategy,
                                reward_strategy=reward_strategy)
b_strategy = StableBaselinesTradingStrategy(model=PPO2)
strategy.environment = environment
strategy.run(epochs=10)
```

Use Case #2: Run a Live Strategy

```
import ccxt
from tensortrade.environments import TradingEnvironment
from tensortrade.strategies import StableBaselinesTradingStrategy
from tensortrade.exchanges.live import CCXTExchange
coinbase = ccxt.coinbasepro(...) # your credentials go here in dictionary form
exchange = CCXTExchange(exchange=coinbase,
                        timeframe='1h',
                        base_instrument='USD',
                        feature_pipeline=feature_pipeline)
environment = TradingEnvironment(exchange=exchange,
                                action_strategy=action_strategy,
                                reward_strategy=reward_strategy)
strategy.environment = environment
strategy.restore_agent(path="../agents/ppo_btc/1h")
live_performance = strategy.run(steps=0, trade_callback=episode_cb)
```

1.37 TensorforceTradingStrategy

A trading strategy capable of self tuning, training, and evaluating with Tensorforce.

1.37.1 Class Parameters

- `environment`
 - A `TradingEnvironment` instance for the agent to trade within.
- `agent`
 - A `Tensorforce` agent or agent specification.
- `model`
 - The runner will automatically save the best agent
- `policy`
 - The RL policy to train the agent’s model with. Defaults to ‘`MlpPolicy`’.
- `_model_kwargs`

1.37.2 Properties and Setters

- `environment`

- A `TradingEnvironment` instance for the agent to trade within.

1.37.3 Functions

- `restore_agent`
 - Deserialize the strategy's learning agent from a file.
 - **parameters:**
 - * `path`
 - The `str` path of the file the agent specification is stored in.
- `save_agent`
 - Serialize the learning agent to a file for restoring later.
 - **parameters:**
 - * `path`
 - The `str` path of the file to store the agent specification in.
- `tune`
 - `Function Not Implemented`
- `run`
 - Runs all of the episodes specified.
 - **parameters:**
 - * `steps`
 - * `episodes`
 - * `episode_callback`

1.37.4 Use Cases

Use Case #1: Run a Strategy

```
from stable_baselines import PPO2
from tensortrade.strategies import TensorforceTradingStrategy

agent_spec = {
    "type": "ppo_agent",
    "step_optimizer": {
        "type": "adam",
        "learning_rate": 1e-4
    },
    "discount": 0.99,
    "likelihood_ratio_clipping": 0.2,
}

network_spec = [
    dict(type='dense', size=64, activation="tanh"),
    dict(type='dense', size=32, activation="tanh")
]
```

(continues on next page)

(continued from previous page)

```
a_strategy = TensorforceTradingStrategy(environment=environment,
                                         agent_spec=agent_spec,
                                         network_spec=network_spec)

a_strategy.run(epochs=10)
```

Use Case #2: Run a Live Strategy

```
import ccxt
from tensortrade.environments import TradingEnvironment
from tensortrade.strategies import StableBaselinesTradingStrategy
from tensortrade.exchanges.live import CCXTExchange
coinbase = ccxt.coinbasepro(...) # your credentials go here in dictionary form
exchange = CCXTExchange(exchange=coinbase,
                        timeframe='1h',
                        base_instrument='USD',
                        feature_pipeline=feature_pipeline)

environment = TradingEnvironment(exchange=exchange,
                                action_strategy=action_strategy,
                                reward_strategy=reward_strategy)

agent_spec = {
    "type": "ppo_agent",
    "step_optimizer": {
        "type": "adam",
        "learning_rate": 1e-4
    },
    "discount": 0.99,
    "likelihood_ratio_clipping": 0.2,
}

network_spec = [
    dict(type='dense', size=64, activation="tanh"),
    dict(type='dense', size=32, activation="tanh")
]

a_strategy = TensorforceTradingStrategy(environment=environment,
                                         agent_spec=agent_spec,
                                         network_spec=network_spec)

strategy.environment = environment
strategy.restore_agent(path="../agents/ppo_btc/1h")
live_performance = strategy.run(steps=0, trade_callback=episode_cb)
```

1.38 tensortrade

1.38.1 tensortrade package

Subpackages

tenstrade.actions package

`tenstrade.actions.get (identifier)`

Gets the *ActionScheme* that matches with the identifier.

Parameters `identifier` (`str`) – The identifier for the *ActionScheme*

Raises `KeyError` – if identifier is not associated with any *ActionScheme*

Return type *ActionScheme*

Submodules

tenstrade.actions.action_scheme module

class `tenstrade.actions.action_scheme.ActionScheme`

Bases: *tenstrade.base.component.Component*

A discrete action scheme for determining the action to take at each timestep within a trading environments.

`__len__()`

The discrete action space produced by the action scheme.

Return type `int`

actions

`get_order (action, portfolio)`

Get the order to be executed on the exchange based on the action provided.

Parameters

- **action** (`int`) – The action to be converted into an order.
- **exchange** – The exchange the action will be executed on.
- **portfolio** (*Portfolio*) – The portfolio of wallets used to execute the action.

Return type *Order*

Returns The order to be executed on the exchange this time step.

`registered_name = 'actions'`

`reset()`

An optional reset method, which will be called each time the environment is reset.

`set_pairs (exchange_pairs)`

class `tenstrade.actions.action_scheme.AddActions (left, right)`

Bases: *tenstrade.actions.action_scheme.ActionScheme*

`get_order (action, portfolio)`

Get the order to be executed on the exchange based on the action provided.

Parameters

- **action** – The action to be converted into an order.
- **exchange** – The exchange the action will be executed on.
- **portfolio** – The portfolio of wallets used to execute the action.

Returns The order to be executed on the exchange this time step.

`set_pairs(exchange_pairs)`

tenstrade.actions.dynamic_orders module

```
class tenstrade.actions.dynamic_orders.DynamicOrders(criteria=None,
                                                    trade_sizes=10,
                                                    trade_type=<TradeType.MARKET:
                                                    'market'>, or-
                                                    der_listener=None)
```

Bases: `tenstrade.actions.action_scheme.ActionScheme`

A discrete action scheme that determines actions based on a list of trading pairs, order criteria, and trade sizes.

```
__init__(criteria=None, trade_sizes=10, trade_type=<TradeType.MARKET:
         'market'>, or-
         der_listener=None)
```

Parameters

- **pairs** – A list of trading pairs to select from when submitting an order.
- **TradingPair** (*(e.g.)*) –
- **criteria** (`Union[List[ForwardRef], ForwardRef]`) – A list of order criteria to select from when submitting an order.
- **MarketOrder, LimitOrder w/ price, StopLoss, etc.** (*(e.g.)*) –
- **trade_sizes** (`Union[List[float], int]`) – A list of trade sizes to select from when submitting an order.
- **'[1, 1/3]' = 100% or 33% of balance is tradeable. '4' = 25%, 50%, 75%, or 100% of balance is tradeable.** (*(e.g.)*) –
- **order_listener** (*optional*) – An optional listener for order events executed by this action scheme.

action_space

The discrete action space produced by the action scheme.

Return type `Discrete`

criteria

A list of order criteria to select from when submitting an order. (e.g. MarketOrderCriteria, LimitOrderCriteria, StopLossCriteria, CustomCriteria, etc.)

Return type `List[ForwardRef]`

get_order(action, portfolio)

Get the order to be executed on the exchange based on the action provided.

Parameters

- **action** (`int`) – The action to be converted into an order.
- **exchange** – The exchange the action will be executed on.
- **portfolio** (`Portfolio`) – The portfolio of wallets used to execute the action.

Return type `Order`

Returns The order to be executed on the exchange this time step.

trade_sizes

A list of trade sizes to select from when submitting an order. (e.g. '[1, 1/3]' = 100% or 33% of balance is tradeable. '4' = 25%, 50%, 75%, or 100% of balance is tradeable.)

Return type `List[float]`

tenstrade.actions.managed_risk_orders module

```
class tenstrade.actions.managed_risk_orders.ManagedRiskOrders (stop_loss_percentages=[0.02,
                                                                    0.04,    0.06],
                                                                    take_profit_percentages=[0.01,
                                                                    0.02,    0.03],
                                                                    trade_sizes=10,
                                                                    trade_type=<TradeType.MARKET:
                                                                    'market'>,
                                                                    dura-
                                                                    tion=None, or-
                                                                    der_listener=None)
```

Bases: `tenstrade.actions.action_scheme.ActionScheme`

A discrete action scheme that determines actions based on managing risk, through setting a follow-up stop loss and take profit on every order.

```
__init__ (stop_loss_percentages=[0.02, 0.04, 0.06], take_profit_percentages=[0.01, 0.02, 0.03],
          trade_sizes=10, trade_type=<TradeType.MARKET: 'market'>, duration=None, or-
          der_listener=None)
```

Parameters

- **pairs** – A list of trading pairs to select from when submitting an order.
- **TradingPair** (*(e.g.)*) –
- **stop_loss_percentages** (`Union[List[float], float]`) – A list of possible stop loss percentages for each order.
- **take_profit_percentages** (`Union[List[float], float]`) – A list of possible take profit percentages for each order.
- **trade_sizes** (`Union[List[float], int]`) – A list of trade sizes to select from when submitting an order.
- **'[1, 1/3]' = 100% or 33% of balance is tradable. '4' = 25%, 50%, 75%, or 100% of balance is tradable.)** (*(e.g.)*) –
- **order_listener** (*optional*) – An optional listener for order events executed by this action scheme.

action_space

The discrete action space produced by the action scheme.

Return type `Discrete`

get_order (action, portfolio)

Get the order to be executed on the exchange based on the action provided.

Parameters

- **action** (`int`) – The action to be converted into an order.
- **exchange** – The exchange the action will be executed on.

- **portfolio** (`Portfolio`) – The portfolio of wallets used to execute the action.

Return type `Order`

Returns The order to be executed on the exchange this time step.

reset ()

An optional reset method, which will be called each time the environment is reset.

stop_loss_percentages

A list of order percentage losses to select a stop loss from when submitting an order. (e.g. 0.01 = sell if price drops 1%, 0.15 = 15%, etc.)

Return type `List[float]`

take_profit_percentages

A list of order percentage gains to select a take profit from when submitting an order. (e.g. 0.01 = sell if price rises 1%, 0.15 = 15%, etc.)

Return type `List[float]`

trade_sizes

A list of trade sizes to select from when submitting an order. (e.g. '[1, 1/3]' = 100% or 33% of balance is tradable. '4' = 25%, 50%, 75%, or 100% of balance is tradable.)

Return type `List[float]`

tenstrade.agents package

Subpackages

tenstrade.agents.parallel package

Submodules

tenstrade.agents.parallel.parallel_dqn_agent module

class `tenstrade.agents.parallel.parallel_dqn_agent.ParallelDQNAgent` (*create_env*, *model=None*)

Bases: `tenstrade.agents.agent.Agent`

get_action (*state*, ***kwargs*)

Return type `int`

restore (*path*, ***kwargs*)

save (*path*, ***kwargs*)

train (*n_steps=None*, *n_episodes=None*, *save_every=None*, *save_path=None*, *callback=None*, ***kwargs*)

update_networks (*model*)

update_target_network ()

tensortrade.agents.parallel.parallel_dqn_model module

```
class tensortrade.agents.parallel.parallel_dqn_model.ParallelDQNModel (create_env,
                                                                    pol-
                                                                    icy_network=None)

    Bases: object

    get_action (state, **kwargs)

        Return type int

    restore (path, **kwargs)

    save (path, **kwargs)

    update_networks (model)

    update_target_network ()
```

tensortrade.agents.parallel.parallel_dqn_optimizer module

```
class tensortrade.agents.parallel.parallel_dqn_optimizer.ParallelDQNOptimizer (model,
                                                                    n_envs,
                                                                    mem-
                                                                    ory_queue,
                                                                    model_update_queue,
                                                                    done_queue,
                                                                    dis-
                                                                    count_factor=0.99,
                                                                    batch_size=128,
                                                                    learn-
                                                                    ing_rate=0.0001,
                                                                    mem-
                                                                    ory_capacity=100)

    Bases: multiprocessing.context.Process

    run ()

        Method to be run in sub-process; can be overridden in sub-class
```

tensortrade.agents.parallel.parallel_dqn_trainer module

```
class tensortrade.agents.parallel.parallel_dqn_trainer.ParallelDQNTrainer (agent,
                                                                    cre-
                                                                    ate_env,
                                                                    mem-
                                                                    ory_queue,
                                                                    model_update_queue,
                                                                    done_queue,
                                                                    n_steps,
                                                                    n_episodes,
                                                                    eps_end=0.05,
                                                                    eps_start=0.99,
                                                                    eps_decay_steps=2000,
                                                                    up-
                                                                    date_target_every=2)

    Bases: multiprocessing.context.Process
```

run()

Method to be run in sub-process; can be overridden in sub-class

tensortrade.agents.parallel.parallel_queue module

class tensortrade.agents.parallel.parallel_queue.**ParallelQueue**

Bases: multiprocessing.queue.Queue

A portable implementation of multiprocessing.Queue. Because of multithreading / multiprocessing semantics, Queue.qsize() may raise the NotImplementedError exception on Unix platforms like Mac OS X where sem_getvalue() is not implemented. This subclass addresses this problem by using a synchronized shared counter (initialized to zero) and increasing / decreasing its value every time the put() and get() methods are called, respectively. This not only prevents NotImplementedError from being raised, but also allows us to implement a reliable version of both qsize() and empty().

empty()

Reliable implementation of multiprocessing.Queue.empty()

get (*args, **kwargs)

put (*args, **kwargs)

qsize()

Reliable implementation of multiprocessing.Queue.qsize()

class tensortrade.agents.parallel.parallel_queue.**SharedCounter** (n=0)

Bases: object

A synchronized shared counter. The locking done by multiprocessing.Value ensures that only a single process or thread may read or write the in-memory ctypes object. However, in order to do n += 1, Python performs a read followed by a write, so a second process may read the old value before the new one is written by the first process. The solution is to use a multiprocessing.Lock to guarantee the atomicity of the modifications to Value. This class comes almost entirely from Eli Bendersky's blog: <http://eli.thegreenplace.net/2012/01/04/shared-counter-with-pythons-multiprocessing/>

increment (n=1)

Increment the counter by n (default = 1)

value

Return the value of the counter

Submodules

tensortrade.agents.a2c_agent module

References

- <http://inoryy.com/post/tensorflow2-deep-reinforcement-learning/#agent-interface>

class tensortrade.agents.a2c_agent.**A2CAgent** (env, shared_network=None, ac-

tor_network=None, critic_network=None)

Bases: tensortrade.agents.agent.Agent

get_action (state, **kwargs)

Return type int

restore (path, **kwargs)

```

save (path, **kwargs)

train (n_steps=None, n_episodes=None, save_every=None, save_path=None, callback=None,
        **kwargs)

class tensortrade.agents.a2c_agent.A2CTransition (state, action, reward, done, value)
    Bases: tuple

    action
        Alias for field number 1

    done
        Alias for field number 3

    reward
        Alias for field number 2

    state
        Alias for field number 0

    value
        Alias for field number 4

```

tensortrade.agents.agent module

```

class tensortrade.agents.agent.Agent
    Bases: tensortrade.base.core.Identifiable

    get_action (state, **kwargs)
        Return type int

    restore (path, **kwargs)

    save (path, **kwargs)

    train (n_steps=None, n_episodes=10000, save_every=None, save_path=None, callback=None,
            **kwargs)

```

tensortrade.agents.dqn_agent module

References

- <https://towardsdatascience.com/deep-reinforcement-learning-build-a-deep-q-network-dqn-to-play-cartpole-with-tensorflow-2-a>
- https://pytorch.org/tutorials/intermediate/reinforcement_q_learning.html#dqn-algorithm

```

class tensortrade.agents.dqn_agent.DQNAgent (env, policy_network=None)
    Bases: tensortrade.agents.agent.Agent

    get_action (state, **kwargs)
        Return type int

    restore (path, **kwargs)

    save (path, **kwargs)

    train (n_steps=None, n_episodes=None, save_every=None, save_path=None, callback=None,
            **kwargs)

```

```
class tensortrade.agents.dqn_agent.DQNTransition(state, action, reward, next_state,
                                                done)
    Bases: tuple

    action
        Alias for field number 1

    done
        Alias for field number 4

    next_state
        Alias for field number 3

    reward
        Alias for field number 2

    state
        Alias for field number 0
```

tensortrade.agents.replay_memory module

```
class tensortrade.agents.replay_memory.ReplayMemory(capacity,
                                                    transition_type=<class
                                                    'tensor-
                                                    trade.agents.replay_memory.Transition'>)

    Bases: object

    head (batch_size)
        Return type List[namedtuple]

    push (*args)

    sample (batch_size)
        Return type List[namedtuple]

    tail (batch_size)
        Return type List[namedtuple]

class tensortrade.agents.replay_memory.Transition(state, action, reward, done)
    Bases: tuple

    action
        Alias for field number 1

    done
        Alias for field number 3

    reward
        Alias for field number 2

    state
        Alias for field number 0
```

tensortrade.base package

Submodules

tenstrade.base.clock module

```
class tenstrade.base.clock.Clock
    Bases: object

    increment()

    now()
        Return type str

    now_formatted()
        Return type str

    reset()

    start
        Return type int

    step
        Return type int
```

tenstrade.base.component module

```
class tenstrade.base.component.Component
    Bases: abc.ABC, tenstrade.base.component.ContextualizedMixin, tenstrade.base.core.Identifiable

    default (key, value, kwargs=None)

    registered_name = None

class tenstrade.base.component.ContextualizedMixin
    Bases: object

    This class is to be mixed in with any class that must function in a contextual setting.

    context
        Return type Context

class tenstrade.base.component.InitContextMeta
    Bases: abc.ABCMeta

    Metaclass that executes __init__ of instance in it's base.
```

tenstrade.base.context module

```
class tenstrade.base.context.Context (base_instrument=USD, **kwargs)
    Bases: collections.UserDict

    A context that is injected into every instance of a class that is a subclass of component.

    Parameters base_instrument (Instrument) – The exchange symbol of the instrument to
        store/measure value in.

    base_instrument
        Return type Instrument
```

```
class tensortrade.base.context.TradingContext (base_instrument=USD, **config)
    Bases: collections.UserDict
```

A class for objects that put themselves in a *Context* using the *with* statement.

The implementation for this class is heavily borrowed from the pymc3 library and adapted with the design goals of TensorTrade in mind.

Parameters

- **shared** – A context that is shared between all components that are made under the overarching *TradingContext*.
- **exchanges** – A context that is specific to components with a registered name of *exchanges*.
- **actions** – A context that is specific to components with a registered name of *actions*.
- **rewards** – A context that is specific to components with a registered name of *rewards*.
- **features** – A context that is specific to components with a registered name of *features*.

Warning: If there is a conflict in the contexts of different components because they were initialized under different contexts, can have undesirable effects. Therefore, a warning should be made to the user indicating that using components together that have conflicting contexts can lead to unwanted behavior.

Reference:

- <https://github.com/pymc-devs/pymc3/blob/master/pymc3/model.py>

```
__enter__ ()
```

Adds a new context to the context stack.

This method is used for a *with* statement and adds a *TradingContext* to the context stack. The new context on the stack is then used by every class that subclasses *Component* the initialization of its instances.

actions

Return type `dict`

```
contexts = <_thread._local object>
```

exchanges

Return type `dict`

features

Return type `dict`

```
classmethod from_json (path)
```

```
classmethod from_yaml (path)
```

```
classmethod get_context ()
```

Gets the deepest context on the stack.

```
classmethod get_contexts ()
```

rewards

Return type `dict`

shared

Return type `dict`

slippage

Return type `dict`

tensortrade.base.core module

class `tensortrade.base.core.Identifiable`

Bases: `object`

Identifiable mixin for adding a unique *id* property to instances of a class.

id

Return type `str`

class `tensortrade.base.core.Listener`

Bases: `object`

class `tensortrade.base.core.Observable`

Bases: `object`

attach (*listener*)

detach (*listener*)

listeners

class `tensortrade.base.core.TimeIndexed`

Bases: `object`

clock

Return type `Clock`

class `tensortrade.base.core.TimedIdentifiable`

Bases: `tensortrade.base.core.Identifiable`, `tensortrade.base.core.TimeIndexed`

clock

Return type `Clock`

created_at

tensortrade.base.exceptions module

exception `tensortrade.base.exceptions.IncompatibleInstrumentOperation` (*left*,
right,
**args*)

Bases: `Exception`

exception `tensortrade.base.exceptions.IncompatiblePriceQuantityOperation` (*left*,
right,
**args*)

Bases: `Exception`

exception `tensortrade.base.exceptions.IncompatibleRecipePath` (*order*,
**args*, *recipe*)

Bases: `Exception`

exception `tenstrade.base.exceptions.IncompatibleTradingPairOperation` (*left*,
right,
**args*)

Bases: `Exception`

exception `tenstrade.base.exceptions.InsufficientFunds` (*balance*, *size*, **args*)

Bases: `Exception`

exception `tenstrade.base.exceptions.InvalidNegativeQuantity` (*size*, **args*)

Bases: `Exception`

exception `tenstrade.base.exceptions.InvalidNonNumericQuantity`

Bases: `Exception`

exception `tenstrade.base.exceptions.InvalidOrderQuantity` (*size*, **args*)

Bases: `Exception`

exception `tenstrade.base.exceptions.InvalidTradingPair` (*base*, *quote*, **args*)

Bases: `Exception`

exception `tenstrade.base.exceptions.QuantityOpPathMismatch`

Bases: `Exception`

tenstrade.base.registry module

`tenstrade.base.registry.get_major_component_names()`

`tenstrade.base.registry.get_registered_name(component)`

`tenstrade.base.registry.get_registry()`

`tenstrade.base.registry.register(component, registered_name)`

`tenstrade.base.registry.registered_names()`

tenstrade.data package

Subpackages

tenstrade.data.internal package

Submodules

tenstrade.data.internal.helpers module

`tenstrade.data.internal.helpers.create_internal_feed(portfolio)`

tenstrade.data.internal.wallet module

`tenstrade.data.internal.wallet.create_wallet_source(wallet, include_worth=True)`

tensortrade.data.stream package

Submodules

tensortrade.data.stream.feed module

```
class tensortrade.data.stream.feed.DataFeed (nodes=None)
    Bases: tensortrade.data.stream.node.Node

    compile ()
    forward ()
    gather ()
    has_next ()
        Return type bool
    next ()
    reset ()
    run ()
    static toposort (edges)
```

tensortrade.data.stream.listeners module

```
class tensortrade.data.stream.listeners.FeedListener
    Bases: object
    on_next (data)

class tensortrade.data.stream.listeners.NodeListener
    Bases: object
    on_next (data)
```

tensortrade.data.stream.node module

References

- <https://github.com/tensorflow/tensorflow/blob/master/tensorflow/python/module/module.py>
- https://github.com/tensorflow/tensorflow/blob/master/tensorflow/python/keras/engine/base_layer.py
- <https://github.com/tensorflow/tensorflow/blob/master/tensorflow/python/keras/engine/node.py>

```
class tensortrade.data.stream.node.Module (name)
    Bases: tensortrade.data.stream.node.Node

    CONTEXTS = []
    add_node (node)
    build ()
    flatten ()
    forward ()
```

```

    reset ()
class tensortrade.data.stream.node.Node (name)
    Bases: tensortrade.base.core.Observable
    forward ()
    has_next ()
    name
    reset ()
    run ()
    value

```

tensortrade.data.stream.source module

```

class tensortrade.data.stream.source.Stream (name, array=None)
    Bases: tensortrade.data.stream.node.Node
    forward ()
    has_next ()
        Return type bool
    reset ()

```

tensortrade.data.stream.transform module

```

class tensortrade.data.stream.transform.BinOp (name, op)
    Bases: tensortrade.data.stream.node.Node
    forward ()
    has_next ()
    reset ()

class tensortrade.data.stream.transform.Condition (name, condition)
    Bases: tensortrade.data.stream.node.Module
    build ()
    has_next ()

class tensortrade.data.stream.transform.Forward (node)
    Bases: tensortrade.data.stream.transform.Lambda

class tensortrade.data.stream.transform.Lambda (name, extract, obj)
    Bases: tensortrade.data.stream.node.Node
    forward ()
    has_next ()
    reset ()

class tensortrade.data.stream.transform.Reduce (name, func)
    Bases: tensortrade.data.stream.node.Node
    forward ()

```

```

    has_next ()
    reset ()
class tenstrade.data.stream.transform.Select (selector)
    Bases: tenstrade.data.stream.node.Node
    forward ()
    has_next ()
    reset ()

```

tenstrade.environments package

`tenstrade.environments.get (identifier)`
 Gets the *TradingEnvironment* that matches with the identifier.

Parameters `identifier (str)` – The identifier for the *TradingEnvironment*

Raises `KeyError` – if identifier is not associated with any *TradingEnvironment*

Return type *TradingEnvironment*

Subpackages

tenstrade.environments.render package

Submodules

tenstrade.environments.render.matplotlib_trading_chart module

Submodules

tenstrade.environments.observation_history module

```

class tenstrade.environments.observation_history.ObservationHistory (window_size)
    Bases: object
    observe ()
        Returns the rows to be observed by the agent.
        Return type array
    push (row)
        Saves an observation.
    reset ()

```

tenstrade.environments.trading_environment module

```
class tenstrade.environments.trading_environment.TradingEnvironment(portfolio,  
                                                                    ac-  
                                                                    tion_scheme,  
                                                                    re-  
                                                                    ward_scheme,  
                                                                    feed=None,  
                                                                    win-  
                                                                    dow_size=1,  
                                                                    use_internal=True,  
                                                                    **kwargs)
```

Bases: `gym.core.Env`, `tenstrade.base.core.TimeIndexed`

A trading environments made for use with Gym-compatible reinforcement learning algorithms.

```
__init__(portfolio, action_scheme, reward_scheme, feed=None, window_size=1, use_internal=True,  
         **kwargs)
```

Parameters

- **portfolio** (`Union[Portfolio, str]`) – The *Portfolio* of wallets used to submit and execute orders from.
- **action_scheme** (`Union[ActionScheme, str]`) – The component for transforming an action into an *Order* at each timestep.
- **reward_scheme** (`Union[RewardScheme, str]`) – The component for determining the reward at each timestep.
- **feed** (*optional*) – The pipeline of features to pass the observations through.
- **kwargs** (*optional*) – Additional arguments for tuning the environments, logging, etc.

action_scheme

The component for transforming an action into an *Order* at each time step.

Return type `ActionScheme`

agent_id = `None`

broker

The broker used to execute orders within the environment.

Return type `Broker`

close()

Utility method to clean environment before closing.

compile()

Sets the observation space and the action space of the environment. Creates the internal feed and sets initialization for different components.

episode_id = `None`

episode_trades

A dictionary of trades made this episode, organized by order id.

Return type `Dict[str, ForwardRef]`

portfolio

The portfolio of instruments currently held on this exchange.

Return type `Portfolio`

render (*mode='none'*)

Renders the environment via matplotlib.

reset ()

Resets the state of the environments and returns an initial observation.

Return type `array`

Returns The episode's initial observation.

reward_scheme

The component for determining the reward at each time step.

Return type `RewardScheme`

step (*action*)

Run one timestep within the environments based on the specified action.

Parameters **action** (`int`) – The trade action provided by the agent for this timestep.

Return type `Tuple[array, float, bool, dict]`

Returns *observation* (`pandas.DataFrame`) – Provided by the environments's exchange, often OHLCV or tick trade history data points. *reward* (`float`): An size corresponding to the benefit earned by the action taken this timestep. *done* (`bool`): If *True*, the environments is complete and should be restarted. *info* (`dict`): Any auxiliary, diagnostic, or debugging information to output.

tenstrade.exchanges package

`tenstrade.exchanges.get_service` (*identifier*)

Gets the *ExecutionService* that matches with the identifier.

Parameters **identifier** (`str`) – The identifier for the *ExecutionService*

Raises `KeyError` – if identifier is not associated with any *ExecutionService*

Return type `Callable`

Subpackages

tenstrade.exchanges.services package

Subpackages

tenstrade.exchanges.services.data package

Submodules

tenstrade.exchanges.services.data.ccxt module

tenstrade.exchanges.services.data.interactive_brokers module

tenstrade.exchanges.services.data.robinhood module

tenstrade.exchanges.services.execution package

Submodules

tenstrade.exchanges.services.execution.ccxt module

tenstrade.exchanges.services.execution.interactive_brokers module

tenstrade.exchanges.services.execution.robinhood module

tenstrade.exchanges.services.execution.simulated module

tenstrade.exchanges.services.execution.simulated.**contain_price**(*price*, *options*)

Return type `float`

tenstrade.exchanges.services.execution.simulated.**contain_size**(*size*, *options*)

Return type `float`

tenstrade.exchanges.services.execution.simulated.**execute_buy_order**(*order*,
base_wallet,
quote_wallet,
current_price,
options,
exchange_id,
clock)

Return type `Trade`

tenstrade.exchanges.services.execution.simulated.**execute_order**(*order*,
base_wallet,
quote_wallet,
current_price,
options, *exchange_id*,
clock)

Return type `Trade`

tenstrade.exchanges.services.execution.simulated.**execute_sell_order**(*order*,
base_wallet,
quote_wallet,
current_price,
options,
exchange_id,
clock)

Return type `Trade`

tenstrade.exchanges.services.slippage package

`tenstrade.exchanges.services.slippage.get(identifier)`

Gets the *SlippageModel* that matches with the identifier.

Parameters `identifier` (`str`) – The identifier for the *SlippageModel*

Raises `KeyError` – if identifier is not associated with any *SlippageModel*

Return type *SlippageModel*

Submodules

tenstrade.exchanges.services.slippage.random_slippage_model module

class `tenstrade.exchanges.services.slippage.random_slippage_model.RandomUniformSlippageModel`

Bases: `tenstrade.exchanges.services.slippage.slippage_model.SlippageModel`

A uniform random slippage model.

`__init__` (`max_slippage_percent=3.0`)

Parameters `max_slippage_percent` (`float`) – The maximum random slippage to be applied to the fill price. Defaults to 3.0 (i.e. 3%).

`adjust_trade` (`trade`)

Simulate slippage on a trade ordered on a specific exchange.

Parameters

- `trade` (*Trade*) – The trade executed on the exchange.
- `**kwargs` – Any other arguments necessary for the model.

Return type *Trade*

Returns A filled *Trade* with the *price* and *size* adjusted for slippage.

tenstrade.exchanges.services.slippage.slippage_model module

class `tenstrade.exchanges.services.slippage.slippage_model.SlippageModel`

Bases: `tenstrade.base.component.Component`

A model for simulating slippage on an exchange trade.

`adjust_trade` (`trade, **kwargs`)

Simulate slippage on a trade ordered on a specific exchange.

Parameters

- `trade` (*Trade*) – The trade executed on the exchange.
- `**kwargs` – Any other arguments necessary for the model.

Return type *Trade*

Returns A filled *Trade* with the *price* and *size* adjusted for slippage.

`registered_name = 'slippage'`

Submodules

tenstrade.exchanges.exchange module

class tenstrade.exchanges.exchange.**Exchange** (*name, service, options=None*)

Bases: `tenstrade.data.stream.node.Module`, `tenstrade.base.component.Component`, `tenstrade.base.core.TimedIdentifiable`

An abstract exchange for use within a trading environment.

build()

execute_order (*order, portfolio*)

Execute an order on the exchange.

Parameters

- **order** (`Order`) – The order to execute.
- **portfolio** (`Portfolio`) – The portfolio to use.

has_next()

is_pair_tradable (*trading_pair*)

Whether or not the specified trading pair is tradable on this exchange.

Parameters **trading_pair** (`TradingPair`) – The `TradingPair` to test the tradability of.

Return type `bool`

Returns A bool designating whether or not the pair is tradable.

options

quote_price (*trading_pair*)

The quote price of a trading pair on the exchange, denoted in the base instrument.

Parameters **trading_pair** (`TradingPair`) – The `TradingPair` to get the quote price for.

Return type `float`

Returns The quote price of the specified trading pair, denoted in the base instrument.

registered_name = 'exchanges'

reset()

class tenstrade.exchanges.exchange.**ExchangeOptions** (*commission=0.003, min_trade_size=1e-06, max_trade_size=1000000.0, min_trade_price=1e-08, max_trade_price=100000000.0, is_live=False*)

Bases: `object`

tenstrade.instruments package

Submodules

tenstrade.instruments.instrument module

```
class tenstrade.instruments.instrument.Instrument (symbol, precision, name=None)
    Bases: object
    A financial instrument for use in trading.

    name
        Return type str

    precision
        Return type int

    symbol
        Return type str
```

tenstrade.instruments.quantity module

```
class tenstrade.instruments.quantity.Quantity (instrument, size=0, path_id=None)
    Bases: object
    An size of a financial instrument for use in trading.

    free()

    instrument
        Return type Instrument

    is_locked
        Return type bool

    lock_for (path_id)

    path_id
        Return type str

    size
        Return type float

    static validate (left, right)
        Return type Tuple[Quantity, Quantity]
```

tenstrade.instruments.trading_pair module

```
class tenstrade.instruments.trading_pair.TradingPair (base, quote)
    Bases: object
    A pair of financial instruments to be traded on a specific exchange.

    base

    quote
```

tenstrade.orders package

Subpackages

tenstrade.orders.criteria package

Submodules

tenstrade.orders.criteria.criteria module

```

class tenstrade.orders.criteria.criteria.AndCriteria (left, right)
    Bases: tenstrade.orders.criteria.criteria.CriteriaBinOp

class tenstrade.orders.criteria.criteria.Criteria
    Bases: object

    A criteria to be satisfied before an order will be executed.

    check (order, exchange)

        Return type bool

class tenstrade.orders.criteria.criteria.CriteriaBinOp (left, right, op, op_str)
    Bases: tenstrade.orders.criteria.criteria.Criteria

    check (order, exchange)

        Return type bool

class tenstrade.orders.criteria.criteria.NotCriteria (criteria)
    Bases: tenstrade.orders.criteria.criteria.Criteria

    check (order, exchange)

        Return type bool

class tenstrade.orders.criteria.criteria.OrCriteria (left, right)
    Bases: tenstrade.orders.criteria.criteria.CriteriaBinOp

class tenstrade.orders.criteria.criteria.XorCriteria (left, right)
    Bases: tenstrade.orders.criteria.criteria.CriteriaBinOp

```

tenstrade.orders.criteria.limit module

```

class tenstrade.orders.criteria.limit.Limit (limit_price)
    Bases: tenstrade.orders.criteria.criteria.Criteria

    An order criteria that allows execution when the quote price for a trading pair is at or below a specific price,
    hidden from the public order book.

    check (order, exchange)

        Return type bool

```

tenstrade.orders.criteria.stop module

```

class tenstrade.orders.criteria.stop.Stop (direction, percent)
    Bases: tenstrade.orders.criteria.criteria.Criteria

```

An order criteria that allows execution when the quote price for a trading pair is above or below a specific price.

check (*order*, *exchange*)

Return type `bool`

class `tenstrade.orders.criteria.stop.StopDirection`

Bases: `enum.Enum`

An enumeration.

DOWN = `'down'`

UP = `'up'`

tenstrade.orders.criteria.timed module

class `tenstrade.orders.criteria.timed.Timed` (*duration*)

Bases: `tenstrade.orders.criteria.criteria.Criteria`

check (*order*, *exchange*)

Submodules

tenstrade.orders.broker module

class `tenstrade.orders.broker.Broker` (*exchanges*)

Bases: `tenstrade.orders.order_listener.OrderListener`, `tenstrade.base.core.TimeIndexed`

A broker for handling the execution of orders on multiple exchanges. Orders are kept in a virtual order book until they are ready to be executed.

cancel (*order*)

exchanges

The list of exchanges the broker will execute orders on.

Return type `List[ForwardRef]`

executed

The dictionary of orders the broker has executed since resetting, organized by order id

Return type `Dict[str, Order]`

on_fill (*order*, *exchange*, *trade*)

reset ()

submit (*order*)

trades

The dictionary of trades the broker has executed since resetting, organized by order id.

Return type `Dict[str, ForwardRef]`

unexecuted

The list of orders the broker is waiting to execute, when their criteria is satisfied.

Return type `List[Order]`

update()

tenstrade.orders.create module

tenstrade.orders.create.hidden_limit_order(step, side, pair, price, size, portfolio, start=None, end=None)

tenstrade.orders.create.limit_order(step, side, pair, price, size, portfolio, start=None, end=None)

tenstrade.orders.create.market_order(step, side, pair, price, size, portfolio)

tenstrade.orders.create.risk_managed_order(step, side, trade_type, pair, price, size, down_percent, up_percent, portfolio, start=None, end=None)

tenstrade.orders.order module

class tenstrade.orders.order.Order(step, side, trade_type, pair, quantity, portfolio, price, criteria=None, path_id=None, start=None, end=None)

Bases: *tenstrade.base.core.TimedIdentifiable*

Responsibilities of the Order:

1. Confirming its own validity.
2. Tracking its trades and reporting it back to the broker.
3. Managing movement of quantities from order to order.
4. Generating the next order in its path given that there is a 'OrderSpec' for how to make the next order.
5. Managing its own state changes when it can.

add_order_spec(order_spec)

Return type *Order*

attach(listener)

base_instrument

Return type *Instrument*

cancel()

complete(exchange)

Return type *Order*

detach(listener)

execute(exchange)

fill(exchange, trade)

is_buy

Return type *bool*

is_complete()

is_executable_on(exchange)

is_limit_order
 Return type `bool`

is_market_order
 Return type `bool`

is_sell
 Return type `bool`

price
 Return type `float`

quote_instrument
 Return type *Instrument*

release()

size
 Return type `float`

to_dict()

to_json()

trades

class `tenstrade.orders.order.OrderStatus`

Bases: `enum.Enum`

An enumeration.

CANCELLED = 'cancelled'

FILLED = 'filled'

OPEN = 'open'

PARTIALLY_FILLED = 'partially_filled'

PENDING = 'pending'

`tenstrade.orders.order_listener` module

class `tenstrade.orders.order_listener.OrderListener`

Bases: `object`

on_cancel (*order*)

on_complete (*order*, *exchange*)

on_execute (*order*, *exchange*)

on_fill (*order*, *exchange*, *trade*)

`tenstrade.orders.order_spec` module

class `tenstrade.orders.order_spec.OrderSpec` (*side*, *trade_type*, *pair*, *criteria=None*)

Bases: *tenstrade.base.core.Identifiable*

`create_order` (*order*, *exchange*)

Return type *Order*

`to_dict` ()

tensortrade.orders.trade module

class `tensortrade.orders.trade.Trade` (*order_id*, *exchange_id*, *step*, *pair*, *side*, *trade_type*,
quantity, *price*, *commission*)

Bases: *tensortrade.base.core.TimedIdentifiable*

A trade object for use within trading environments.

`__init__` (*order_id*, *exchange_id*, *step*, *pair*, *side*, *trade_type*, *quantity*, *price*, *commission*)

Parameters

- **order_id** (*str*) – The id of the order that created the trade.
- **exchange_id** (*str*) – The id of the exchange the trade was executed on.
- **step** (*int*) – The timestep the trade was made during the trading episode.
- **pair** (*TradingPair*) – The trading pair of the instruments in the trade.
- **BTC/USDT**, **ETH/BTC**, **ADA/BTC**, **AAPL/USD**, **NQ1!/USD**, **CAD/USD**,
etc) ((*e.g.*)) –
- **side** (*TradeSide*) – Whether the quote instrument is being bought or sold.
- **BUY** = trade the base_instrument for the quote_instrument
in the pair. **SELL** = trade the quote_instrument for the
base_instrument) ((*e.g.*)) –
- **size** – The size of the base instrument in the trade.
- **1000 shares**, **6.50 satoshis**, **2.3 contracts**, **etc**) ((*e.g.*)) –
- **price** (*float*) – The price paid per quote instrument in terms of the base instrument.
- **10000 represents \$10,000.00 if the base_instrument is "USD"**
") ((*e.g.*)) –
- **commission** (*Quantity*) – The commission paid for the trade in terms of the base
instrument.
- **10000 represents \$10,000.00 if the base_instrument is "USD"**
") –

base_instrument

Return type *Instrument*

commission

Return type *Quantity*

is_buy

Return type *bool*

is_limit_order

Return type *bool*

is_market_order

```

        Return type bool
    is_sell
        Return type bool
    price
        Return type float
    quote_instrument
        Return type Instrument
    size
        Return type float
    to_dict()
    to_json()
class tenstrade.orders.trade.TradeSide
    Bases: enum.Enum
    An enumeration.
    BUY = 'buy'
    SELL = 'sell'
    instrument (pair)
        Return type Instrument
class tenstrade.orders.trade.TradeType
    Bases: enum.Enum
    An enumeration.
    LIMIT = 'limit'
    MARKET = 'market'

```

tenstrade.rewards package

```

tenstrade.rewards.get(identifier)
    Gets the RewardScheme that matches with the identifier.

    Parameters identifier (str) – The identifier for the RewardScheme
    Raises KeyError – if identifier is not associated with any RewardScheme
    Return type RewardScheme

```

Submodules

tenstrade.rewards.reward_scheme module

```

class tenstrade.rewards.reward_scheme.RewardScheme
    Bases: tenstrade.base.component.Component, tenstrade.base.core.TimeIndexed
    get_reward (portfolio)

```

Parameters `portfolio` (`Portfolio`) – The portfolio being used by the environment.

Return type `float`

Returns A float corresponding to the benefit earned by the action taken this timestep.

`registered_name = 'rewards'`

`reset()`

Optionally implementable method for resetting stateful schemes.

tenstrade.rewards.risk_adjusted_returns module

class `tenstrade.rewards.risk_adjusted_returns.RiskAdjustedReturns` (`return_algorithm='sharpe'`,
`risk_free_rate=0.0`,
`tar-`
`get_returns=0.0`)

Bases: `tenstrade.rewards.reward_scheme.RewardScheme`

A reward scheme that rewards the agent for increasing its net worth, while penalizing more volatile strategies.

`__init__` (`return_algorithm='sharpe'`, `risk_free_rate=0.0`, `target_returns=0.0`)

Parameters

- **return_algorithm** (*optional*) – The risk-adjusted return metric to use. Options are 'sharpe' and 'sortino'. Defaults to 'sharpe'.
- **risk_free_rate** (*optional*) – The risk free rate of returns to use for calculating metrics. Defaults to 0.
- **target_returns** (*optional*) – The target returns per period for use in calculating the sortino ratio. Default to 0.

`get_reward` (`portfolio`)

Return the reward corresponding to the selected risk-adjusted return metric.

Return type `float`

tenstrade.rewards.simple_profit module

class `tenstrade.rewards.simple_profit.SimpleProfit` (`window_size=1`)

Bases: `tenstrade.rewards.reward_scheme.RewardScheme`

A simple reward scheme that rewards the agent for incremental increases in net worth.

`get_reward` (`portfolio`)

Rewards the agent for incremental increases in net worth over a sliding window.

Parameters `portfolio` (`Portfolio`) – The portfolio being used by the environment.

Return type `float`

Returns The incremental increase in net worth over the previous `window_size` timesteps.

`reset()`

Optionally implementable method for resetting stateful schemes.

tensortrade.stochastic package

Subpackages

tensortrade.stochastic.processes package

Submodules

tensortrade.stochastic.processes.brownian_motion module

tensortrade.stochastic.processes.brownian_motion.**brownian_motion_levels** (*params*)

Constructs a price sequence whose returns evolve according to brownian motion.

Parameters *params* (*ModelParameters*) – ModelParameters The parameters for the stochastic model.

Returns A price sequence which follows brownian motion

tensortrade.stochastic.processes.brownian_motion.**brownian_motion_log_returns** (*params*)

Constructs a Wiener process (Brownian Motion).

References

- http://en.wikipedia.org/wiki/Wiener_process

Parameters *params* (*ModelParameters*) – ModelParameters The parameters for the stochastic model.

Returns brownian motion log returns

tensortrade.stochastic.processes.cox module

tensortrade.stochastic.processes.cox.**cox** (*base_price=1*, *base_volume=1*,
start_date='2010-01-01',
start_date_format='%Y-%m-%d',
times_to_generate=1000, *time_frame='1h'*,
params=None)

tensortrade.stochastic.processes.cox.**cox_ingersoll_ross_levels** (*params*)

Constructs the rate levels of a mean-reverting Cox-Ingersoll-Ross process. Used to model interest rates as well as stochastic volatility in the Heston model. We pass a correlated Brownian motion process into the method from which the interest rate levels are constructed because the returns between the underlying and the stochastic volatility should be correlated. The other

correlated process is used in the Heston model.

Parameters *params* – ModelParameters The parameters for the stochastic model.

Returns The interest rate levels for the CIR process.

tensortrade.stochastic.processes.fbm module

```
tensortrade.stochastic.processes.fbm.fbm(base_price=1, base_volume=1,
                                          start_date='2010-01-01',
                                          start_date_format='%Y-%m-%d',
                                          times_to_generate=1000, hurst=0.61,
                                          time_frame='1h')
```

tensortrade.stochastic.processes.gbm module

```
tensortrade.stochastic.processes.gbm.gbm(base_price=1, base_volume=1,
                                          start_date='2010-01-01',
                                          start_date_format='%Y-%m-%d',
                                          times_to_generate=1000, time_frame='1h',
                                          model_params=None)
```

tensortrade.stochastic.processes.gbm.geometric_brownian_motion_levels(*params*)
Constructs a sequence of price levels for an asset which evolves according to a geometric brownian motion.

Parameters *params* (*ModelParameters*) – ModelParameters The parameters for the stochastic model.

Returns The price levels for the asset

tensortrade.stochastic.processes.gbm.geometric_brownian_motion_log_returns(*params*)
Constructs a sequence of log returns which, when exponentiated, produces a random Geometric Brownian Motion (GBM). The GBM is the stochastic process underlying the Black-Scholes options pricing formula.

Parameters *params* (*ModelParameters*) – ModelParameters The parameters for the stochastic model.

Returns The log returns of a geometric brownian motion process

tensortrade.stochastic.processes.heston module

tensortrade.stochastic.processes.heston.cox_ingersoll_ross_heston(*params*)
Constructs the rate levels of a mean-reverting cox ingersoll ross process. Used to model interest rates as well as stochastic volatility in the Heston model. The returns between the underlying and the stochastic volatility should be correlated we pass a correlated Brownian motion process into the method from which the interest rate levels are constructed. The other correlated process are used in the Heston model.

Parameters *params* – ModelParameters The parameters for the stochastic model.

Returns The interest rate levels for the CIR process

tensortrade.stochastic.processes.heston.geometric_brownian_motion_jump_diffusion_levels(*params*)
Converts a sequence of gbm jmp returns into a price sequence which evolves according to a geometric brownian motion but can contain jumps at any point in time.

Parameters *params* (*ModelParameters*) – ModelParameters The parameters for the stochastic model.

Returns The price levels

tensortrade.stochastic.processes.heston.geometric_brownian_motion_jump_diffusion_log_returns(*params*)
Constructs combines a geometric brownian motion process (log returns) with a jump diffusion process (log returns) to produce a sequence of gbm jump returns.

Parameters `params` (*ModelParameters*) – ModelParameters The parameters for the stochastic model.

Returns A GBM process with jumps in it

`tenstrade.stochastic.processes.heston.get_correlated_geometric_brownian_motions` (*params*, *correlation_matrix*, *n*)

Constructs a basket of correlated asset paths using the Cholesky decomposition method.

Parameters

- **params** (*ModelParameters*) – ModelParameters The parameters for the stochastic model.
- **correlation_matrix** (*array*) – np.array An n x n correlation matrix.
- **n** (*int*) – int Number of assets (number of paths to return)

Returns n correlated log return geometric brownian motion processes

`tenstrade.stochastic.processes.heston.heston` (*base_price=1*, *base_volume=1*, *start_date='2010-01-01'*, *start_date_format='%Y-%m-%d'*, *times_to_generate=1000*, *time_frame='1h'*, *params=None*)

`tenstrade.stochastic.processes.heston.heston_construct_correlated_path` (*params*, *brownian_motion_one*)

This method is a simplified version of the Cholesky decomposition method for just two assets. It does not make use of matrix algebra and is therefore quite easy to implement.

Parameters

- **params** (*ModelParameters*) – ModelParameters The parameters for the stochastic model.
- **brownian_motion_one** (*array*) – np.array (Not filled)

Returns A correlated brownian motion path.

`tenstrade.stochastic.processes.heston.heston_model_levels` (*params*)

NOTE - this method is dodgy! Need to debug! The Heston model is the geometric brownian motion model with stochastic volatility. This stochastic volatility is given by the cox ingersoll ross process. Step one on this method is to construct two correlated GBM processes. One is used for the underlying asset prices and the other is used for the stochastic volatility levels.

Parameters `params` – ModelParameters The parameters for the stochastic model.

Returns The prices for an underlying following a Heston process

`tenstrade.stochastic.processes.heston.jump_diffusion_process` (*params*)

Produces a sequence of Jump Sizes which represent a jump diffusion process. These jumps are combined with a geometric brownian motion (log returns) to produce the Merton model.

Parameters `params` (*ModelParameters*) – ModelParameters The parameters for the stochastic model.

Returns jump sizes for each point in time (mostly zeroes if jumps are infrequent)

tensortrade.stochastic.processes.merton module

```
tensortrade.stochastic.processes.merton.merton(base_price=1,          base_volume=1,
                                                start_date='2010-01-01',
                                                start_date_format='%Y-%m-
%d',          times_to_generate=1000,
                                                time_frame='1h', params=None)
```

tensortrade.stochastic.processes.ornstein_uhlenbeck module

```
tensortrade.stochastic.processes.ornstein_uhlenbeck.ornstein(base_price=1,
                                                                base_volume=1,
                                                                start_date='2010-
01-01',
                                                                start_date_format='%Y-
%m-%d',
                                                                times_to_generate=1000,
                                                                time_frame='1h',
                                                                params=None)
```

```
tensortrade.stochastic.processes.ornstein_uhlenbeck.ornstein_uhlenbeck_levels(params)
Constructs the rate levels of a mean-reverting ornstein uhlenbeck process.
```

Parameters `params` – ModelParameters The parameters for the stochastic model.

Returns The interest rate levels for the Ornstein Uhlenbeck process

tensortrade.stochastic.utils package

Submodules

tensortrade.stochastic.utils.helpers module

```
tensortrade.stochastic.utils.helpers.convert_to_prices(param, log_returns)
This method converts a sequence of log returns into normal returns (exponentiation) and then computes a price
sequence given a starting price, param.all_s0. :param param: the model parameters object :param log_returns:
the log returns to exponentiated :return:
```

```
tensortrade.stochastic.utils.helpers.convert_to_returns(log_returns)
This method exponentiates a sequence of log returns to get daily returns. :param log_returns: the log returns to
exponentiated :return: the exponentiated returns
```

```
tensortrade.stochastic.utils.helpers.generate(price_fn,          base_price=1,
                                                base_volume=1,          start_date='2010-
01-01',          start_date_format='%Y-
%m-%d',          times_to_generate=1000,
                                                time_frame='1h', params=None)
```

```
tensortrade.stochastic.utils.helpers.get_delta(time_frame)
```

```
tensortrade.stochastic.utils.helpers.scale_times_to_generate(times_to_generate,
                                                                time_frame)
```

tenstrade.stochastic.utils.parameters module

```
class tenstrade.stochastic.utils.parameters.ModelParameters (all_s0, all_time,  

all_delta,  

all_sigma,  

gbm_mu,  

jumps_lamda=0.0,  

jumps_sigma=0.0,  

jumps_mu=0.0,  

cir_a=0.0,  

cir_mu=0.0,  

all_r0=0.0,  

cir_rho=0.0,  

ou_a=0.0,  

ou_mu=0.0,  

heston_a=0.0, he-  

ston_mu=0.0, he-  

ston_vol0=0.0)
```

Bases: `object`

Encapsulates model parameters

`tenstrade.stochastic.utils.parameters.default` (*base_price, t_gen, delta*)

`tenstrade.stochastic.utils.parameters.random` (*base_price, t_gen, delta*)

tenstrade.wallets package

`tenstrade.wallets.get` (*identifier*)

Gets the *TradingStrategy* that matches with the identifier.

Parameters *identifier* (`str`) – The identifier for the *TradingStrategy*

Raises `KeyError` – if identifier is not associated with any *TradingStrategy*

Return type `Portfolio`

Submodules

tenstrade.wallets.portfolio module

```
class tenstrade.wallets.portfolio.Portfolio (base_instrument, wallets=None,  

order_listener=None, perfor-  

mance_listener=None)  

Bases: tenstrade.base.component.Component, tenstrade.base.core.  

TimedIdentifiable, tenstrade.data.stream.listeners.FeedListener
```

A portfolio of wallets on exchanges.

add (*wallet*)

balance (*instrument*)

The total balance of the portfolio in a specific instrument available for use.

Return type `Quantity`

balances

The current unlocked balance of each instrument over all wallets.

Return type `List[Quantity]`

base_balance

The current balance of the base instrument over all wallets.

Return type `Quantity`

base_instrument

The exchange instrument used to measure value and performance statistics.

Return type `Instrument`

exchange_pairs

Return type `List[ForwardRef]`

exchanges

Return type `List[ForwardRef]`

static find_keys (*data*)

get_wallet (*exchange_id*, *instrument*)

initial_balance

The initial balance of the base instrument over all wallets, set by calling *reset*.

Return type `Quantity`

initial_net_worth

locked_balance (*instrument*)

The total balance of the portfolio in a specific instrument locked in orders.

Return type `Quantity`

locked_balances

The current locked balance of each instrument over all wallets.

Return type `List[Quantity]`

net_worth

Calculate the net worth of the active account on thenge.

Return type `float`

Returns The total portfolio value of the active account on the exchange.

on_next (*data*)

order_listener

The order listener to set for all orders executed by this portfolio.

Return type `Instrument`

performance

The performance of the active account on the exchange since the last reset.

Return type `DataFrame`

Returns A *pandas.DataFrame* with the locked and unlocked balance of each wallet at each time step.

performance_listener

The performance listener to send all portfolio updates to.

Return type *Instrument*

profit_loss

Calculate the percentage change in net worth since the last reset.

Return type *float*

Returns The percentage change in net worth since the last reset. i.e. A return value of 2 would indicate a 100% increase in net worth (e.g. \$100 -> \$200)

registered_name = 'portfolio'

remove (*wallet*)

remove_pair (*exchange, instrument*)

reset ()

total_balance (*instrument*)

The total balance of the portfolio in a specific instrument, both available for use and locked in orders.

Return type *Quantity*

total_balances

The current total balance of each instrument over all wallets.

Return type *List[Quantity]*

wallets

Return type *List[Wallet]*

tenstrade.wallets.wallet module

class tenstrade.wallets.wallet.**Wallet** (*exchange, quantity*)

Bases: *tenstrade.base.core.Identifiable*

A wallet stores the balance of a specific instrument on a specific exchange.

balance

The total balance of the wallet available for use.

Return type *Quantity*

deallocate (*path_id*)

exchange

Return type *Exchange*

classmethod **from_tuple** (*wallet_tuple*)

instrument

Return type *Instrument*

locked

Return type *Dict[str, Quantity]*

locked_balance

The total balance of the wallet locked in orders.

Return type *Quantity*

total_balance

The total balance of the wallet, both available for use and locked in orders.

Return type *Quantity*

Submodules

tensortrade.version module

t

tenstrade, 48
tenstrade.actions, 49
tenstrade.actions.action_scheme, 49
tenstrade.actions.dynamic_orders, 50
tenstrade.actions.managed_risk_orders, 51
tenstrade.agents, 52
tenstrade.agents.a2c_agent, 54
tenstrade.agents.agent, 55
tenstrade.agents.dqn_agent, 55
tenstrade.agents.parallel, 52
tenstrade.agents.parallel.parallel_dqn_agent, 52
tenstrade.agents.parallel.parallel_dqn_model, 53
tenstrade.agents.parallel.parallel_dqn_optimizer, 53
tenstrade.agents.parallel.parallel_dqn_trainer, 53
tenstrade.agents.parallel.parallel_queue, 54
tenstrade.agents.replay_memory, 56
tenstrade.base, 56
tenstrade.base.clock, 57
tenstrade.base.component, 57
tenstrade.base.context, 57
tenstrade.base.core, 59
tenstrade.base.exceptions, 59
tenstrade.base.registry, 60
tenstrade.data, 60
tenstrade.data.internal, 60
tenstrade.data.internal.helpers, 60
tenstrade.data.internal.wallet, 60
tenstrade.data.stream, 61
tenstrade.data.stream.feed, 61
tenstrade.data.stream.listeners, 61
tenstrade.data.stream.node, 61
tenstrade.data.stream.source, 62
tenstrade.data.stream.transform, 62
tenstrade.environments, 63
tenstrade.environments.observation_history, 63
tenstrade.environments.render, 63
tenstrade.environments.trading_environment, 64
tenstrade.exchanges, 65
tenstrade.exchanges.exchange, 68
tenstrade.exchanges.services, 65
tenstrade.exchanges.services.data, 65
tenstrade.exchanges.services.data.ccxt, 65
tenstrade.exchanges.services.data.interactive_brokers, 65
tenstrade.exchanges.services.data.robinhood, 65
tenstrade.exchanges.services.execution, 66
tenstrade.exchanges.services.execution.ccxt, 66
tenstrade.exchanges.services.execution.interactive_brokers, 66
tenstrade.exchanges.services.execution.robinhood, 66
tenstrade.exchanges.services.execution.simulated, 66
tenstrade.exchanges.services.slippage, 67
tenstrade.exchanges.services.slippage.random_slippage, 67
tenstrade.exchanges.services.slippage.slippage_model, 67
tenstrade.instruments, 68
tenstrade.instruments.instrument, 69
tenstrade.instruments.quantity, 69
tenstrade.instruments.trading_pair, 69
tenstrade.orders, 70
tenstrade.orders.broker, 71

- tenstrade.orders.create, [72](#)
- tenstrade.orders.criteria, [70](#)
- tenstrade.orders.criteria.criteria,
[70](#)
- tenstrade.orders.criteria.limit, [70](#)
- tenstrade.orders.criteria.stop, [70](#)
- tenstrade.orders.criteria.timed, [71](#)
- tenstrade.orders.order, [72](#)
- tenstrade.orders.order_listener, [73](#)
- tenstrade.orders.order_spec, [73](#)
- tenstrade.orders.trade, [74](#)
- tenstrade.rewards, [75](#)
- tenstrade.rewards.reward_scheme, [75](#)
- tenstrade.rewards.risk_adjusted_returns,
[76](#)
- tenstrade.rewards.simple_profit, [76](#)
- tenstrade.stochastic, [77](#)
- tenstrade.stochastic.processes, [77](#)
- tenstrade.stochastic.processes.brownian_motion,
[77](#)
- tenstrade.stochastic.processes.cox,
[77](#)
- tenstrade.stochastic.processes.fbm,
[78](#)
- tenstrade.stochastic.processes.gbm,
[78](#)
- tenstrade.stochastic.processes.heston,
[78](#)
- tenstrade.stochastic.processes.merton,
[80](#)
- tenstrade.stochastic.processes.ornstein_uhlenbeck,
[80](#)
- tenstrade.stochastic.utils, [80](#)
- tenstrade.stochastic.utils.helpers,
[80](#)
- tenstrade.stochastic.utils.parameters,
[81](#)
- tenstrade.version, [84](#)
- tenstrade.wallets, [81](#)
- tenstrade.wallets.portfolio, [81](#)
- tenstrade.wallets.wallet, [83](#)

Symbols

Symbols		attribute), 50	
__enter__()	(tensor-trade.base.context.TradingContext method), 58	action_space	(tensor-trade.actions.managed_risk_orders.ManagedRiskOrders attribute), 51
__init__()	(tensor-trade.actions.dynamic_orders.DynamicOrders method), 50	actions	(tensortrade.actions.action_scheme.ActionScheme attribute), 49
__init__()	(tensor-trade.actions.managed_risk_orders.ManagedRiskOrders method), 51	actions	(tensortrade.base.context.TradingContext attribute), 58
__init__()	(tensor-trade.environments.trading_environment.TradingEnvironment method), 64	ActionScheme	(class in tensor-trade.actions.action_scheme), 49
__init__()	(tensor-trade.exchanges.services.slippage.random_slippage_model.RandomUniformSlippageModel method), 67	add()	(tensortrade.wallets.portfolio.Portfolio method), 81
__init__()	(tensor-trade.exchanges.services.slippage.random_slippage_model.RandomUniformSlippageModel method), 72	add_node()	(tensortrade.data.stream.node.Module method), 61
__init__()	(tensor-trade.exchanges.services.slippage.random_slippage_model.RandomUniformSlippageModel method), 74	add_order_spec()	(tensortrade.orders.order.Order method), 72
__init__()	(tensor-trade.rewards.risk_adjusted_returns.RiskAdjustedReturns method), 76	AddActions	(class in tensor-trade.actions.action_scheme), 49
__len__()	(tensortrade.actions.action_scheme.ActionScheme method), 49	adjust_trade()	(tensor-trade.exchanges.services.slippage.random_slippage_model.RandomUniformSlippageModel method), 67
		adjust_trade()	(tensor-trade.exchanges.services.slippage.slippage_model.SlippageModel method), 67
A			
A2CAgent	(class in tensortrade.agents.a2c_agent), 54	Agent	(class in tensortrade.agents.agent), 55
A2CTransition	(class in tensor-trade.agents.a2c_agent), 55	agent_id	(tensortrade.environments.trading_environment.TradingEnvironment attribute), 64
action	(tensortrade.agents.a2c_agent.A2CTransition attribute), 55	AndCriteria	(class in tensor-trade.orders.criteria.criteria), 70
action	(tensortrade.agents.dqn_agent.DQNTransition attribute), 56	attach()	(tensortrade.base.core.Observable method), 59
action	(tensortrade.agents.replay_memory.Transition attribute), 56	attach()	(tensortrade.orders.order.Order method), 72
action_scheme	(tensor-trade.environments.trading_environment.TradingEnvironment attribute), 64	B	
action_space	(tensor-trade.actions.dynamic_orders.DynamicOrders attribute), 50	balance	(tensortrade.wallets.wallet.Wallet attribute), 83
		balance()	(tensortrade.wallets.portfolio.Portfolio method), 81
		balances	(tensortrade.wallets.portfolio.Portfolio attribute), 81

base (*tensortrade.instruments.trading_pair.TradingPair attribute*), 69

base_balance (*tensortrade.wallets.portfolio.Portfolio attribute*), 82

base_instrument (*tensortrade.base.context.Context attribute*), 57

base_instrument (*tensortrade.orders.order.Order attribute*), 72

base_instrument (*tensortrade.orders.trade.Trade attribute*), 74

base_instrument (*tensortrade.orders.trade.Trade attribute*), 82

BinOp (*class in tensortrade.data.stream.transform*), 62

Broker (*class in tensortrade.orders.broker*), 71

broker (*tensortrade.environments.trading_environment.TradingEnvironment attribute*), 64

brownian_motion_levels() (*in module tensortrade.stochastic.processes.brownian_motion*), 77

brownian_motion_log_returns() (*in module tensortrade.stochastic.processes.brownian_motion*), 77

build() (*tensortrade.data.stream.node.Module method*), 61

build() (*tensortrade.data.stream.transform.Condition method*), 62

build() (*tensortrade.exchanges.exchange.Exchange method*), 68

BUY (*tensortrade.orders.trade.TradeSide attribute*), 75

C

cancel() (*tensortrade.orders.broker.Broker method*), 71

cancel() (*tensortrade.orders.order.Order method*), 72

CANCELLED (*tensortrade.orders.order.OrderStatus attribute*), 73

check() (*tensortrade.orders.criteria.criteria.Criteria method*), 70

check() (*tensortrade.orders.criteria.criteria.CriteriaBinOp method*), 70

check() (*tensortrade.orders.criteria.criteria.NotCriteria method*), 70

check() (*tensortrade.orders.criteria.limit.Limit method*), 70

check() (*tensortrade.orders.criteria.stop.Stop method*), 71

check() (*tensortrade.orders.criteria.timed.Timed method*), 71

Clock (*class in tensortrade.base.clock*), 57

clock (*tensortrade.base.core.TimedIdentifiable attribute*), 59

clock (*tensortrade.base.core.TimeIndexed attribute*), 59

close() (*tensortrade.environments.trading_environment.TradingEnvironment method*), 64

commission (*tensortrade.orders.trade.Trade attribute*), 74

compile() (*tensortrade.data.stream.feed.DataFeed method*), 61

compile() (*tensortrade.environments.trading_environment.TradingEnvironment method*), 64

complete() (*tensortrade.orders.order.Order method*), 72

Component (*class in tensortrade.base.component*), 57

Condition (*class in tensortrade.data.stream.transform*), 62

contain_price() (*in module tensortrade.exchanges.services.execution.simulated*), 66

contain_size() (*in module tensortrade.exchanges.services.execution.simulated*), 66

Context (*class in tensortrade.base.context*), 57

context (*tensortrade.base.component.ContextualizedMixin attribute*), 57

contexts (*tensortrade.base.context.TradingContext attribute*), 58

CONTEXTS (*tensortrade.data.stream.node.Module attribute*), 61

ContextualizedMixin (*class in tensortrade.base.component*), 57

convert_to_prices() (*in module tensortrade.stochastic.utils.helpers*), 80

convert_to_returns() (*in module tensortrade.stochastic.utils.helpers*), 80

cox() (*in module tensortrade.stochastic.processes.cox*), 77

cox_ingersoll_ross_heston() (*in module tensortrade.stochastic.processes.heston*), 78

cox_ingersoll_ross_levels() (*in module tensortrade.stochastic.processes.cox*), 77

create_internal_feed() (*in module tensortrade.data.internal.helpers*), 60

create_order() (*tensortrade.orders.order_spec.OrderSpec method*), 73

create_wallet_source() (*in module tensortrade.data.internal.wallet*), 60

created_at (*tensortrade.base.core.TimedIdentifiable attribute*), 59

Criteria (*class in tensortrade.orders.criteria.criteria*), 70

criteria (*tensortrade.actions.dynamic_orders.DynamicOrders attribute*), 50

CriteriaBinOp (*class in tensortrade.orders.criteria.criteria*), 70

D

`DataFeed` (class in `tensortrade.data.stream.feed`), 61
`deallocate()` (`tensortrade.wallets.wallet.Wallet` method), 83
`default()` (in module `tensortrade.stochastic.utils.parameters`), 81
`default()` (`tensortrade.base.component.Component` method), 57
`detach()` (`tensortrade.base.core.Observable` method), 59
`detach()` (`tensortrade.orders.order.Order` method), 72
`done` (`tensortrade.agents.a2c_agent.A2CTransition` attribute), 55
`done` (`tensortrade.agents.dqn_agent.DQNTransition` attribute), 56
`done` (`tensortrade.agents.replay_memory.Transition` attribute), 56
`DOWN` (`tensortrade.orders.criteria.stop.StopDirection` attribute), 71
`DQNAgent` (class in `tensortrade.agents.dqn_agent`), 55
`DQNTransition` (class in `tensortrade.agents.dqn_agent`), 55
`DynamicOrders` (class in `tensortrade.actions.dynamic_orders`), 50

E

`empty()` (`tensortrade.agents.parallel.parallel_queue.ParallelQueue` method), 54
`episode_id` (`tensortrade.environments.trading_environment.TradingEnvironment` attribute), 64
`episode_trades` (`tensortrade.environments.trading_environment.TradingEnvironment` attribute), 64
`Exchange` (class in `tensortrade.exchanges.exchange`), 68
`exchange` (`tensortrade.wallets.wallet.Wallet` attribute), 83
`exchange_pairs` (`tensortrade.wallets.portfolio.Portfolio` attribute), 82
`ExchangeOptions` (class in `tensortrade.exchanges.exchange`), 68
`exchanges` (`tensortrade.base.context.TradingContext` attribute), 58
`exchanges` (`tensortrade.orders.broker.Broker` attribute), 71
`exchanges` (`tensortrade.wallets.portfolio.Portfolio` attribute), 82
`execute()` (`tensortrade.orders.order.Order` method), 72
`execute_buy_order()` (in module `tensortrade.exchanges.services.execution.simulated`), 66

`execute_order()` (in module `tensortrade.exchanges.services.execution.simulated`), 66
`execute_order()` (`tensortrade.exchanges.exchange.Exchange` method), 68
`execute_sell_order()` (in module `tensortrade.exchanges.services.execution.simulated`), 66
`executed` (`tensortrade.orders.broker.Broker` attribute), 71

F

`fbm()` (in module `tensortrade.stochastic.processes.fbm`), 78
`features` (`tensortrade.base.context.TradingContext` attribute), 58
`FeedListener` (class in `tensortrade.data.stream.listeners`), 61
`fill()` (`tensortrade.orders.order.Order` method), 72
`FILLED` (`tensortrade.orders.order.OrderStatus` attribute), 73
`find_keys()` (`tensortrade.wallets.portfolio.Portfolio` static method), 82
`flatten()` (`tensortrade.data.stream.node.Module` method), 61
`Forward` (class in `tensortrade.data.stream.transform`), 62
`forward()` (`tensortrade.data.stream.feed.DataFeed` method), 61
`forward()` (`tensortrade.data.stream.node.Module` method), 61
`forward()` (`tensortrade.data.stream.node.Node` method), 62
`forward()` (`tensortrade.data.stream.source.Stream` method), 62
`forward()` (`tensortrade.data.stream.transform.BinOp` method), 62
`forward()` (`tensortrade.data.stream.transform.Lambda` method), 62
`forward()` (`tensortrade.data.stream.transform.Reduce` method), 62
`forward()` (`tensortrade.data.stream.transform.Select` method), 63
`free()` (`tensortrade.instruments.quantity.Quantity` method), 69
`from_json()` (`tensortrade.base.context.TradingContext` class method), 58
`from_tuple()` (`tensortrade.wallets.wallet.Wallet` class method), 83
`from_yaml()` (`tensortrade.base.context.TradingContext` class method), 58

G

- `gather()` (*tensortrade.data.stream.feed.DataFeed* method), 61
- `gbm()` (in module *tensortrade.stochastic.processes.gbm*), 78
- `generate()` (in module *tensortrade.stochastic.utils.helpers*), 80
- `geometric_brownian_motion_jump_diffusion_levels()` (in module *tensortrade.stochastic.processes.heston*), 78
- `geometric_brownian_motion_jump_diffusion_log_returns()` (in module *tensortrade.stochastic.processes.heston*), 78
- `geometric_brownian_motion_levels()` (in module *tensortrade.stochastic.processes.gbm*), 78
- `geometric_brownian_motion_log_returns()` (in module *tensortrade.stochastic.processes.gbm*), 78
- `get()` (in module *tensortrade.actions*), 49
- `get()` (in module *tensortrade.environments*), 63
- `get()` (in module *tensortrade.exchanges.services.slippage*), 67
- `get()` (in module *tensortrade.rewards*), 75
- `get()` (in module *tensortrade.wallets*), 81
- `get()` (*tensortrade.agents.parallel.parallel_queue.ParallelQueue* method), 54
- `get_action()` (*tensortrade.agents.a2c_agent.A2CAgent* method), 54
- `get_action()` (*tensortrade.agents.agent.Agent* method), 55
- `get_action()` (*tensortrade.agents.dqn_agent.DQNAgent* method), 55
- `get_action()` (*tensortrade.agents.parallel.parallel_dqn_agent.ParallelDQNAgent* method), 52
- `get_action()` (*tensortrade.agents.parallel.parallel_dqn_model.ParallelDQNModel* method), 53
- `get_context()` (*tensortrade.base.context.TradingContext* class method), 58
- `get_contexts()` (*tensortrade.base.context.TradingContext* class method), 58
- `get_correlated_geometric_brownian_motions()` (in module *tensortrade.stochastic.processes.heston*), 79
- `get_delta()` (in module *tensortrade.stochastic.utils.helpers*), 80
- `get_major_component_names()` (in module *tensortrade.base.registry*), 60
- `get_order()` (*tensortrade.actions.action_scheme.ActionScheme* method), 49
- `get_order()` (*tensortrade.actions.action_scheme.AddActions* method), 49
- `get_order()` (*tensortrade.actions.dynamic_orders.DynamicOrders* method), 50
- `get_order()` (*tensortrade.actions.managed_risk_orders.ManagedRiskOrders* method), 51
- `get_registered_name()` (in module *tensortrade.base.registry*), 60
- `get_registry()` (in module *tensortrade.base.registry*), 60
- `get_reward()` (*tensortrade.rewards.reward_scheme.RewardScheme* method), 75
- `get_reward()` (*tensortrade.rewards.risk_adjusted_returns.RiskAdjustedReturns* method), 76
- `get_reward()` (*tensortrade.rewards.simple_profit.SimpleProfit* method), 76
- `get_service()` (in module *tensortrade.exchanges*), 65
- `get_wallet()` (*tensortrade.wallets.portfolio.Portfolio* method), 82

H

- `has_next()` (*tensortrade.data.stream.feed.DataFeed* method), 61
- `has_next()` (*tensortrade.data.stream.node.Node* method), 62
- `has_next()` (*tensortrade.data.stream.source.Stream* method), 62
- `has_next()` (*tensortrade.data.stream.transform.BinOp* method), 62
- `has_next()` (*tensortrade.data.stream.transform.Condition* method), 62
- `has_next()` (*tensortrade.data.stream.transform.Lambda* method), 62
- `has_next()` (*tensortrade.data.stream.transform.Reduce* method), 62
- `has_next()` (*tensortrade.data.stream.transform.Select* method), 63
- `has_next()` (*tensortrade.exchanges.exchange.Exchange* method), 68

head() (*tenstrade.agents.replay_memory.ReplayMemory* is_limit_order (*tenstrade.orders.trade.Trade* attribute), 56 attribute), 74

heston() (in module *tenstrade.stochastic.processes.heston*), 79

heston_construct_correlated_path() (in module *tenstrade.stochastic.processes.heston*), 79

heston_model_levels() (in module *tenstrade.stochastic.processes.heston*), 79

hidden_limit_order() (in module *tenstrade.orders.create*), 72

I

id (*tenstrade.base.core.Identifiable* attribute), 59

Identifiable (class in *tenstrade.base.core*), 59

IncompatibleInstrumentOperation, 59

IncompatiblePriceQuantityOperation, 59

IncompatibleRecipePath, 59

IncompatibleTradingPairOperation, 59

increment() (*tenstrade.agents.parallel.parallel_queue.SharedCounter* method), 54

increment() (*tenstrade.base.clock.Clock* method), 57

InitContextMeta (class in *tenstrade.base.component*), 57

initial_balance (*tenstrade.wallets.portfolio.Portfolio* attribute), 82

initial_net_worth (*tenstrade.wallets.portfolio.Portfolio* attribute), 82

Instrument (class in *tenstrade.instruments.instrument*), 69

instrument (*tenstrade.instruments.quantity.Quantity* attribute), 69

instrument (*tenstrade.wallets.wallet.Wallet* attribute), 83

instrument() (*tenstrade.orders.trade.TradeSide* method), 75

InsufficientFunds, 60

InvalidNegativeQuantity, 60

InvalidNonNumericQuantity, 60

InvalidOrderQuantity, 60

InvalidTradingPair, 60

is_buy (*tenstrade.orders.order.Order* attribute), 72

is_buy (*tenstrade.orders.trade.Trade* attribute), 74

is_complete() (*tenstrade.orders.order.Order* method), 72

is_executable_on() (*tenstrade.orders.order.Order* method), 72

is_limit_order (*tenstrade.orders.order.Order* attribute), 72

is_locked (*tenstrade.instruments.quantity.Quantity* attribute), 69

is_market_order (*tenstrade.orders.order.Order* attribute), 73

is_market_order (*tenstrade.orders.trade.Trade* attribute), 74

is_pair_tradable() (*tenstrade.exchanges.exchange.Exchange* method), 68

is_sell (*tenstrade.orders.order.Order* attribute), 73

is_sell (*tenstrade.orders.trade.Trade* attribute), 75

J

jump_diffusion_process() (in module *tenstrade.stochastic.processes.heston*), 79

L

Lambda (class in *tenstrade.data.stream.transform*), 62

Limit (class in *tenstrade.orders.criteria.limit*), 70

LIMIT (*tenstrade.orders.trade.TradeType* attribute), 75

limit_order() (in module *tenstrade.orders.create*), 72

Listener (class in *tenstrade.base.core*), 59

listeners (*tenstrade.base.core.Observable* attribute), 59

lock_for() (*tenstrade.instruments.quantity.Quantity* method), 69

locked (*tenstrade.wallets.wallet.Wallet* attribute), 83

locked_balance (*tenstrade.wallets.wallet.Wallet* attribute), 83

locked_balance() (*tenstrade.wallets.portfolio.Portfolio* method), 82

locked_balances (*tenstrade.wallets.portfolio.Portfolio* attribute), 82

M

ManagedRiskOrders (class in *tenstrade.actions.managed_risk_orders*), 51

MARKET (*tenstrade.orders.trade.TradeType* attribute), 75

market_order() (in module *tenstrade.orders.create*), 72

merton() (in module *tenstrade.stochastic.processes.merton*), 80

ModelParameters (class in *tenstrade.stochastic.utils.parameters*), 81

Module (class in *tenstrade.data.stream.node*), 61

N

`name` (*tenstrade.data.stream.node.Node* attribute), 62
`name` (*tenstrade.instruments.instrument.Instrument* attribute), 69
`net_worth` (*tenstrade.wallets.portfolio.Portfolio* attribute), 82
`next()` (*tenstrade.data.stream.feed.DataFeed* method), 61
`next_state` (*tenstrade.agents.dqn_agent.DQNTransition* attribute), 56
`Node` (class in *tenstrade.data.stream.node*), 62
`NodeListener` (class in *tenstrade.data.stream.listeners*), 61
`NotCriteria` (class in *tenstrade.orders.criteria.criteria*), 70
`now()` (*tenstrade.base.clock.Clock* method), 57
`now_formatted()` (*tenstrade.base.clock.Clock* method), 57

O

`Observable` (class in *tenstrade.base.core*), 59
`ObservationHistory` (class in *tenstrade.environments.observation_history*), 63
`observe()` (*tenstrade.environments.observation_history.ObservationHistory* method), 63
`on_cancel()` (*tenstrade.orders.order_listener.OrderListener* method), 73
`on_complete()` (*tenstrade.orders.order_listener.OrderListener* method), 73
`on_execute()` (*tenstrade.orders.order_listener.OrderListener* method), 73
`on_fill()` (*tenstrade.orders.broker.Broker* method), 71
`on_fill()` (*tenstrade.orders.order_listener.OrderListener* method), 73
`on_next()` (*tenstrade.data.stream.listeners.FeedListener* method), 61
`on_next()` (*tenstrade.data.stream.listeners.NodeListener* method), 61
`on_next()` (*tenstrade.wallets.portfolio.Portfolio* method), 82
`OPEN` (*tenstrade.orders.order.OrderStatus* attribute), 73
`options` (*tenstrade.exchanges.exchange.Exchange* attribute), 68
`OrCriteria` (class in *tenstrade.orders.criteria.criteria*), 70
`Order` (class in *tenstrade.orders.order*), 72

`order_listener` (*tenstrade.wallets.portfolio.Portfolio* attribute), 82
`OrderListener` (class in *tenstrade.orders.order_listener*), 73
`OrderSpec` (class in *tenstrade.orders.order_spec*), 73
`OrderStatus` (class in *tenstrade.orders.order*), 73
`ornstein()` (in module *tenstrade.stochastic.processes.ornstein_uhlenbeck*), 80
`ornstein_uhlenbeck_levels()` (in module *tenstrade.stochastic.processes.ornstein_uhlenbeck*), 80

P

`ParallelDQNAgent` (class in *tenstrade.agents.parallel.parallel_dqn_agent*), 52
`ParallelDQNModel` (class in *tenstrade.agents.parallel.parallel_dqn_model*), 53
`ParallelDQNOptimizer` (class in *tenstrade.agents.parallel.parallel_dqn_optimizer*), 53
`ParallelDQNTrainer` (class in *tenstrade.agents.parallel.parallel_dqn_trainer*), 53
`ParallelQueue` (class in *tenstrade.agents.parallel.parallel_queue*), 54
`PARTIALLY_FILLED` (*tenstrade.orders.order.OrderStatus* attribute), 73
`path_id` (*tenstrade.instruments.quantity.Quantity* attribute), 69
`PENDING` (*tenstrade.orders.order.OrderStatus* attribute), 73
`performance` (*tenstrade.wallets.portfolio.Portfolio* attribute), 82
`performance_listener` (*tenstrade.wallets.portfolio.Portfolio* attribute), 82
`Portfolio` (class in *tenstrade.wallets.portfolio*), 81
`portfolio` (*tenstrade.environments.trading_environment.TradingEnvironment* attribute), 64
`precision` (*tenstrade.instruments.instrument.Instrument* attribute), 69
`price` (*tenstrade.orders.order.Order* attribute), 73
`price` (*tenstrade.orders.trade.Trade* attribute), 75
`profit_loss` (*tenstrade.wallets.portfolio.Portfolio* attribute), 83
`push()` (*tenstrade.agents.replay_memory.ReplayMemory* method), 56

[push\(\)](#) (`tensortrade.environments.observation_history.ObservationHistory` method), 63
[put\(\)](#) (`tensortrade.agents.parallel.parallel_queue.ParallelQueue` method), 54
Q
[qsize\(\)](#) (`tensortrade.agents.parallel.parallel_queue.ParallelQueue` method), 54
[Quantity](#) (class in `tensortrade.instruments.quantity`), 69
[QuantityOpPathMismatch](#), 60
[quote](#) (`tensortrade.instruments.trading_pair.TradingPair` attribute), 69
[quote_instrument](#) (`tensortrade.orders.order.Order` attribute), 73
[quote_instrument](#) (`tensortrade.orders.trade.Trade` attribute), 75
[quote_price\(\)](#) (`tensortrade.exchanges.exchange.Exchange` method), 68
R
[random\(\)](#) (in module `tensortrade.stochastic.utils.parameters`), 81
[RandomUniformSlippageModel](#) (class in `tensortrade.exchanges.services.slippage.random_slippage_model`), 67
[Reduce](#) (class in `tensortrade.data.stream.transform`), 62
[register\(\)](#) (in module `tensortrade.base.registry`), 60
[registered_name](#) (`tensortrade.actions.action_scheme.ActionScheme` attribute), 49
[registered_name](#) (`tensortrade.base.component.Component` attribute), 57
[registered_name](#) (`tensortrade.exchanges.exchange.Exchange` attribute), 68
[registered_name](#) (`tensortrade.exchanges.services.slippage.slippage_model.SlippageModel` attribute), 67
[registered_name](#) (`tensortrade.rewards.reward_scheme.RewardScheme` attribute), 76
[registered_name](#) (`tensortrade.wallets.portfolio.Portfolio` attribute), 83
[registered_names\(\)](#) (in module `tensortrade.base.registry`), 60
[release\(\)](#) (`tensortrade.orders.order.Order` method), 73
[remove\(\)](#) (`tensortrade.wallets.portfolio.Portfolio` method), 83
[reset\(\)](#) (`tensortrade.wallets.portfolio.Portfolio` method), 83
[render\(\)](#) (`tensortrade.environments.trading_environment.TradingEnvironment` method), 64
[ReplayMemory](#) (class in `tensortrade.agents.replay_memory`), 56
[reset\(\)](#) (`tensortrade.actions.action_scheme.ActionScheme` method), 49
[reset\(\)](#) (`tensortrade.actions.managed_risk_orders.ManagedRiskOrders` method), 52
[reset\(\)](#) (`tensortrade.base.clock.Clock` method), 57
[reset\(\)](#) (`tensortrade.data.stream.feed.DataFeed` method), 61
[reset\(\)](#) (`tensortrade.data.stream.node.Module` method), 61
[reset\(\)](#) (`tensortrade.data.stream.node.Node` method), 62
[reset\(\)](#) (`tensortrade.data.stream.source.Stream` method), 62
[reset\(\)](#) (`tensortrade.data.stream.transform.BinOp` method), 62
[reset\(\)](#) (`tensortrade.data.stream.transform.Lambda` method), 62
[reset\(\)](#) (`tensortrade.data.stream.transform.Reduce` method), 63
[reset\(\)](#) (`tensortrade.data.stream.transform.Select` method), 63
[reset\(\)](#) (`tensortrade.environments.observation_history.ObservationHistory` method), 63
[reset\(\)](#) (`tensortrade.environments.trading_environment.TradingEnvironment` method), 65
[reset\(\)](#) (`tensortrade.exchanges.exchange.Exchange` method), 68
[reset\(\)](#) (`tensortrade.orders.broker.Broker` method), 71
[reset\(\)](#) (`tensortrade.rewards.reward_scheme.RewardScheme` method), 76
[reset\(\)](#) (`tensortrade.rewards.simple_profit.SimpleProfit` method), 76
[reset\(\)](#) (`tensortrade.wallets.portfolio.Portfolio` method), 83
[restore\(\)](#) (`tensortrade.agents.a2c_agent.A2CAgent` method), 54
[restore\(\)](#) (`tensortrade.agents.agent.Agent` method), 55
[restore\(\)](#) (`tensortrade.agents.dqn_agent.DQNAgent` method), 55
[restore\(\)](#) (`tensortrade.agents.parallel.parallel_dqn_agent.ParallelDQNAgent` method), 52
[restore\(\)](#) (`tensortrade.agents.parallel.parallel_dqn_model.ParallelDQNModel` method), 53
[reward](#) (`tensortrade.agents.a2c_agent.A2CTransition` attribute), 55
[reward](#) (`tensortrade.agents.dqn_agent.DQNTransition` attribute), 55

[attribute](#)), 56
[reward](#) ([tenstrade.agents.replay_memory.Transition](#)
[attribute](#)), 56
[reward_scheme](#) ([tenstrade.environments.trading_environment.TradingEnvironment](#)
[attribute](#)), 65
[rewards](#) ([tenstrade.base.context.TradingContext](#) [attribute](#)), 58
[RewardScheme](#) (class in [tenstrade.rewards.reward_scheme](#)), 75
[risk_managed_order\(\)](#) (in module [tenstrade.orders.create](#)), 72
[RiskAdjustedReturns](#) (class in [tenstrade.rewards.risk_adjusted_returns](#)), 76
[run\(\)](#) ([tenstrade.agents.parallel.parallel_dqn_optimizer.ParallelDQNOptimizer](#)
[method](#)), 53
[run\(\)](#) ([tenstrade.agents.parallel.parallel_dqn_trainer.ParallelDQNTrainer](#)
[method](#)), 53
[run\(\)](#) ([tenstrade.data.stream.feed.DataFeed](#) [method](#)),
[61](#)
[run\(\)](#) ([tenstrade.data.stream.node.Node](#) [method](#)), 62

S

[sample\(\)](#) ([tenstrade.agents.replay_memory.ReplayMemory](#)
[method](#)), 56
[save\(\)](#) ([tenstrade.agents.a2c_agent.A2CAgent](#)
[method](#)), 54
[save\(\)](#) ([tenstrade.agents.agent.Agent](#) [method](#)), 55
[save\(\)](#) ([tenstrade.agents.dqn_agent.DQNAgent](#)
[method](#)), 55
[save\(\)](#) ([tenstrade.agents.parallel.parallel_dqn_agent.ParallelDQNAgent](#)
[method](#)), 52
[save\(\)](#) ([tenstrade.agents.parallel.parallel_dqn_model.ParallelDQNModel](#)
[method](#)), 53
[scale_times_to_generate\(\)](#) (in module [tenstrade.stochastic.utils.helpers](#)), 80
[Select](#) (class in [tenstrade.data.stream.transform](#)), 63
[SELL](#) ([tenstrade.orders.trade.TradeSide](#) [attribute](#)), 75
[set_pairs\(\)](#) ([tenstrade.actions.action_scheme.ActionScheme](#)
[method](#)), 49
[set_pairs\(\)](#) ([tenstrade.actions.action_scheme.AddActions](#)
[method](#)), 49
[shared](#) ([tenstrade.base.context.TradingContext](#) [attribute](#)), 58
[SharedCounter](#) (class in [tenstrade.agents.parallel.parallel_queue](#)), 54
[SimpleProfit](#) (class in [tenstrade.rewards.simple_profit](#)), 76
[size](#) ([tenstrade.instruments.quantity.Quantity](#) [attribute](#)), 69
[size](#) ([tenstrade.orders.order.Order](#) [attribute](#)), 73
[size](#) ([tenstrade.orders.trade.Trade](#) [attribute](#)), 75
[slippage](#) ([tenstrade.base.context.TradingContext](#) [attribute](#)), 59
[SlippageModel](#) (class in [tenstrade.exchanges.services.slippage.slippage_model](#)),
[67](#)
[start](#) ([tenstrade.base.clock.Clock](#) [attribute](#)), 57
[state](#) ([tenstrade.agents.a2c_agent.A2CTransition](#) [attribute](#)), 55
[state](#) ([tenstrade.agents.dqn_agent.DQNTransition](#)
[attribute](#)), 56
[state](#) ([tenstrade.agents.replay_memory.Transition](#)
[attribute](#)), 56
[step](#) ([tenstrade.base.clock.Clock](#) [attribute](#)), 57
[step\(\)](#) ([tenstrade.environments.trading_environment.TradingEnvironment](#)
[method](#)), 65
[Stop](#) (class in [tenstrade.orders.criteria.stop](#)), 70
[stop_percentages](#) ([tenstrade.actions.managed_risk_orders.ManagedRiskOrders](#)
[attribute](#)), 52
[StopDirection](#) (class in [tenstrade.orders.criteria.stop](#)), 71
[Stream](#) (class in [tenstrade.data.stream.source](#)), 62
[submit\(\)](#) ([tenstrade.orders.broker.Broker](#) [method](#)),
[71](#)
[symbol](#) ([tenstrade.instruments.instrument.Instrument](#)
[attribute](#)), 69

T

[tail\(\)](#) ([tenstrade.agents.replay_memory.ReplayMemory](#)
[method](#)), 56
[tenstrade.agents.percentages](#) ([tenstrade.actions.managed_risk_orders.ManagedRiskOrders](#)
[attribute](#)), 52
[tenstrade](#) (module), 48
[tenstrade.actions](#) (module), 49
[tenstrade.actions.action_scheme](#) (mod-
[ule](#)), 49
[tenstrade.actions.dynamic_orders](#) (mod-
[ule](#)), 50
[tenstrade.actions.managed_risk_orders](#)
[\(module\)](#), 51
[tenstrade.agents](#) (module), 52
[tenstrade.agents.a2c_agent](#) (module), 54
[tenstrade.agents.agent](#) (module), 55
[tenstrade.agents.dqn_agent](#) (module), 55
[tenstrade.agents.parallel](#) (module), 52
[tenstrade.agents.parallel.parallel_dqn_agent](#)
[\(module\)](#), 52
[tenstrade.agents.parallel.parallel_dqn_model](#)
[\(module\)](#), 53
[tenstrade.agents.parallel.parallel_dqn_optimizer](#)
[\(module\)](#), 53
[tenstrade.agents.parallel.parallel_dqn_trainer](#)
[\(module\)](#), 53

[tensortrade.agents.parallel.parallel_queue](#) [\(module\)](#), 54
[tensortrade.agents.replay_memory](#) [\(module\)](#), 56
[tensortrade.base](#) [\(module\)](#), 56
[tensortrade.base.clock](#) [\(module\)](#), 57
[tensortrade.base.component](#) [\(module\)](#), 57
[tensortrade.base.context](#) [\(module\)](#), 57
[tensortrade.base.core](#) [\(module\)](#), 59
[tensortrade.base.exceptions](#) [\(module\)](#), 59
[tensortrade.base.registry](#) [\(module\)](#), 60
[tensortrade.data](#) [\(module\)](#), 60
[tensortrade.data.internal](#) [\(module\)](#), 60
[tensortrade.data.internal.helpers](#) [\(module\)](#), 60
[tensortrade.data.internal.wallet](#) [\(module\)](#), 60
[tensortrade.data.stream](#) [\(module\)](#), 61
[tensortrade.data.stream.feed](#) [\(module\)](#), 61
[tensortrade.data.stream.listeners](#) [\(module\)](#), 61
[tensortrade.data.stream.node](#) [\(module\)](#), 61
[tensortrade.data.stream.source](#) [\(module\)](#), 62
[tensortrade.data.stream.transform](#) [\(module\)](#), 62
[tensortrade.environments](#) [\(module\)](#), 63
[tensortrade.environments.observation_history](#) [\(module\)](#), 63
[tensortrade.environments.render](#) [\(module\)](#), 63
[tensortrade.environments.trading_environment](#) [\(module\)](#), 64
[tensortrade.exchanges](#) [\(module\)](#), 65
[tensortrade.exchanges.exchange](#) [\(module\)](#), 68
[tensortrade.exchanges.services](#) [\(module\)](#), 65
[tensortrade.exchanges.services.data](#) [\(module\)](#), 65
[tensortrade.exchanges.services.data.ccxt](#) [\(module\)](#), 65
[tensortrade.exchanges.services.data.interactive_brokers](#) [\(module\)](#), 65
[tensortrade.exchanges.services.data.robinhood](#) [\(module\)](#), 65
[tensortrade.exchanges.services.execution](#) [\(module\)](#), 66
[tensortrade.exchanges.services.execution.tenzor](#) [\(module\)](#), 66
[tensortrade.exchanges.services.execution.tenzor_broker](#) [\(module\)](#), 66
[tensortrade.exchanges.services.execution.tenzor_exchange](#) [\(module\)](#), 66
[tensortrade.exchanges.services.execution.simulated](#) [\(module\)](#), 66
[tensortrade.exchanges.services.slippage](#) [\(module\)](#), 67
[tensortrade.exchanges.services.slippage.random_slippage](#) [\(module\)](#), 67
[tensortrade.exchanges.services.slippage.slippage_model](#) [\(module\)](#), 67
[tensortrade.instruments](#) [\(module\)](#), 68
[tensortrade.instruments.instrument](#) [\(module\)](#), 69
[tensortrade.instruments.quantity](#) [\(module\)](#), 69
[tensortrade.instruments.trading_pair](#) [\(module\)](#), 69
[tensortrade.orders](#) [\(module\)](#), 70
[tensortrade.orders.broker](#) [\(module\)](#), 71
[tensortrade.orders.create](#) [\(module\)](#), 72
[tensortrade.orders.criteria](#) [\(module\)](#), 70
[tensortrade.orders.criteria.criteria](#) [\(module\)](#), 70
[tensortrade.orders.criteria.limit](#) [\(module\)](#), 70
[tensortrade.orders.criteria.stop](#) [\(module\)](#), 70
[tensortrade.orders.criteria.timed](#) [\(module\)](#), 71
[tensortrade.orders.order](#) [\(module\)](#), 72
[tensortrade.orders.order_listener](#) [\(module\)](#), 73
[tensortrade.orders.order_spec](#) [\(module\)](#), 73
[tensortrade.orders.trade](#) [\(module\)](#), 74
[tensortrade.rewards](#) [\(module\)](#), 75
[tensortrade.rewards.reward_scheme](#) [\(module\)](#), 75
[tensortrade.rewards.risk_adjusted_returns](#) [\(module\)](#), 76
[tensortrade.rewards.simple_profit](#) [\(module\)](#), 76
[tensortrade.stochastic](#) [\(module\)](#), 77
[tensortrade.stochastic.processes](#) [\(module\)](#), 77
[tensortrade.stochastic.processes.brownian_motion](#) [\(module\)](#), 77
[tensortrade.stochastic.processes.cox_ingersoll](#) [\(module\)](#), 77
[tensortrade.stochastic.processes.fbm](#) [\(module\)](#), 78
[tensortrade.stochastic.processes.gbm](#) [\(module\)](#), 78
[tensortrade.stochastic.processes.heston](#) [\(module\)](#), 78
[tensortrade.stochastic.processes.merton](#) [\(module\)](#), 80

[tenstrade.stochastic.processes.ornstein_uhlen_method](#), 55
[\(module\)](#), 80
[tenstrade.stochastic.utils](#) ([module](#)), 80
[tenstrade.stochastic.utils.helpers](#) ([module](#)), 80
[tenstrade.stochastic.utils.parameters](#) ([module](#)), 81
[tenstrade.version](#) ([module](#)), 84
[tenstrade.wallets](#) ([module](#)), 81
[tenstrade.wallets.portfolio](#) ([module](#)), 81
[tenstrade.wallets.wallet](#) ([module](#)), 83
[Timed](#) ([class in tenstrade.orders.criteria.timed](#)), 71
[TimedIdentifiable](#) ([class in tenstrade.base.core](#)), 59
[TimeIndexed](#) ([class in tenstrade.base.core](#)), 59
[to_dict\(\)](#) ([tenstrade.orders.order.Order](#) [method](#)), 73
[to_dict\(\)](#) ([tenstrade.orders.order_spec.OrderSpec](#) [method](#)), 74
[to_dict\(\)](#) ([tenstrade.orders.trade.Trade](#) [method](#)), 75
[to_json\(\)](#) ([tenstrade.orders.order.Order](#) [method](#)), 73
[to_json\(\)](#) ([tenstrade.orders.trade.Trade](#) [method](#)), 75
[toposort\(\)](#) ([tenstrade.data.stream.feed.DataFeed](#) [static method](#)), 61
[total_balance](#) ([tenstrade.wallets.wallet.Wallet](#) [attribute](#)), 83
[total_balance\(\)](#) ([tenstrade.wallets.portfolio.Portfolio](#) [method](#)), 83
[total_balances](#) ([tenstrade.wallets.portfolio.Portfolio](#) [attribute](#)), 83
[Trade](#) ([class in tenstrade.orders.trade](#)), 74
[trade_sizes](#) ([tenstrade.actions.dynamic_orders.DynamicOrders](#) [attribute](#)), 50
[trade_sizes](#) ([tenstrade.actions.managed_risk_orders.ManagedRiskOrders](#) [attribute](#)), 52
[trades](#) ([tenstrade.orders.broker.Broker](#) [attribute](#)), 71
[trades](#) ([tenstrade.orders.order.Order](#) [attribute](#)), 73
[TradeSide](#) ([class in tenstrade.orders.trade](#)), 75
[TradeType](#) ([class in tenstrade.orders.trade](#)), 75
[TradingContext](#) ([class in tenstrade.base.context](#)), 57
[TradingEnvironment](#) ([class in tenstrade.environments.trading_environment](#)), 64
[TradingPair](#) ([class in tenstrade.instruments.trading_pair](#)), 69
[train\(\)](#) ([tenstrade.agents.a2c_agent.A2CAgent](#) [method](#)), 55
[train\(\)](#) ([tenstrade.agents.agent.Agent](#) [method](#)), 55
[train\(\)](#) ([tenstrade.agents.dqn_agent.DQNAgent](#) [method](#)), 55
[train\(\)](#) ([tenstrade.agents.parallel.parallel_dqn_agent.ParallelDQNAgent](#) [method](#)), 52
[Transition](#) ([class in tenstrade.agents.replay_memory](#)), 56

U

[unexecuted](#) ([tenstrade.orders.broker.Broker](#) [attribute](#)), 71
[UP](#) ([tenstrade.orders.criteria.stop.StopDirection](#) [attribute](#)), 71
[update\(\)](#) ([tenstrade.orders.broker.Broker](#) [method](#)), 71
[update_networks\(\)](#) ([tenstrade.agents.parallel.parallel_dqn_agent.ParallelDQNAgent](#) [method](#)), 52
[update_networks\(\)](#) ([tenstrade.agents.parallel.parallel_dqn_model.ParallelDQNModel](#) [method](#)), 53
[update_target_network\(\)](#) ([tenstrade.agents.parallel.parallel_dqn_agent.ParallelDQNAgent](#) [method](#)), 52
[update_target_network\(\)](#) ([tenstrade.agents.parallel.parallel_dqn_model.ParallelDQNModel](#) [method](#)), 53

V

[validate\(\)](#) ([tenstrade.instruments.quantity.Quantity](#) [static method](#)), 69
[value](#) ([tenstrade.agents.a2c_agent.A2CTransition](#) [attribute](#)), 55
[value](#) ([tenstrade.agents.parallel.parallel_queue.SharedCounter](#) [attribute](#)), 54
[value](#) ([tenstrade.data.stream.node.Node](#) [attribute](#)), 62

W

[Wallet](#) ([class in tenstrade.wallets.wallet](#)), 83
[wallets](#) ([tenstrade.wallets.portfolio.Portfolio](#) [attribute](#)), 83

X

[XorCriteria](#) ([class in tenstrade.orders.criteria.criteria](#)), 70