

AUTOMATIC TRADING SYSTEM

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What is a financial market?

A **financial market** is a market in which people trade financial assets at low transaction cost and at prices that reflect supply and demand.

What can you buy or sell on financial markets?

Direct investing

You can directly invest on:

- ▶ **governments**, which rely on money from investors to bridge gaps between spending and taxes;
- ▶ **companies**, which raise funds to run and expand their business and enable owners to buy and sell their investments;
- ▶ **hard assets**, which are tangible and physical item or object of worth that is own by an individual or a corporation (e.g. currencies, gold, silver, oil,...).

Indirect investments

You can indirectly invest on governments, companies and hard assets through:

- ▶ **derivatives**, which derive their value from a real or financial asset;
- ▶ **funds**, which are a sort of predefined portfolios.

They are used to transfer risk.

Example 1 (Futures)

Let us suppose you own a flight company and you want to plan the costs to purchase crude oil for the next six months. Unfortunately, crude oil's price changes every day. You could buy now the entire amount of crude oil you need. What else can you do?

Example 2 (Futures)

Let us suppose you own an American company and you order a work to be done by an European company. The work will be paid next year and the price has been set in Euro. Unfortunately, the exchange value from Dollars to Euro changes every day. You could exchange now the Dollars into Euro but this means to let the money in a bank for one year. What else can you do?

Definition (Futures)

In a **future contract**, the parties initially agree to buy and sell an asset for a price agreed upon today (the forward price) with delivery and payment occurring at a future point, the delivery date.

How does a transaction work?

12.28.20 - FDXZ5 - DAX INDEX DEC5

Pzo	10.576	▲	-0,33%	Qta	1	OP	Rif	10.610,5	ThAs	0
Pmc	--	Q	--	PL	--	CW	Vol	34.043	Th%	-0,95
--	1	10.575,0	10.576,5	3	--		Max	10.646,5	Min	10.497,5

N.	QTA	PZO	PZO	QTA	N.	ORA	PZO	QTA
1	1	10.575,0	10.576,5	3	3	12.28.20	10.576,0	1
2	3	10.574,5	10.577,0	6	6	12.28.18	10.576,5	1
2	2	10.574,0	10.577,5	7	7	12.28.16	10.577,0	1
4	4	10.573,5	10.578,0	10	10	12.28.15	10.578,0	1
12	14	10.573,0	10.578,5	9	9	12.28.14	10.577,0	4

Simbolo: FDXZ5 Quantità: 1 Prezzo: Limite Pzo

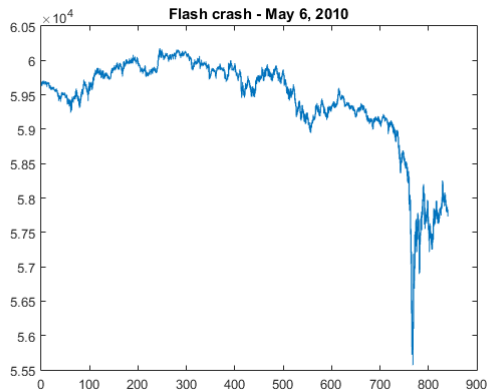
Revoca **ACQUISTA** **VENDI** CaM CaP

Trading and its role

Trading consists of buying and selling securities (such as stocks, and bonds), foreign exchange or financial derivatives electronically to gain money.

The positive effects of trading in financial markets are:

- ▶ reduced cost of transactions;
- ▶ greater liquidity;
- ▶ market efficiency.



A mutual fund company triggered a wave of selling that led to the 2010 Flash Crash.

Automated VS discretionary trading

Automated trading allows traders to establish specific rules for both trade entries and exits that, once programmed, can be automatically executed via a computer.

A **discretionary trader** uses a method of entry or exit that relies on subjective criteria and orders have to be sent to markets manually.

Pros of AT

- ▶ **Minimize emotions:** since trade orders are executed automatically once the trade rules have been met, traders will not be able to hesitate or question the trade.
- ▶ **Ability to backtest:** backtesting applies trading rules to historical market data to determine the viability of the idea.
- ▶ **Preserve discipline:** discipline is often lost due to emotional factors such as fear of taking a loss, or the desire to eke out a little more profit from a trade.
- ▶ **Achieve consistency:** one of the biggest challenges in trading is to *plan the trade and trade the plan*.

- ▶ **Improved order entry speed:** since computers respond immediately to changing market conditions, automated systems are able to generate orders as soon as trade criteria are met.
- ▶ **Diversify trading:** automated trading systems permit the user to trade multiple accounts or various strategies at one time.

Cons of AT

- ▶ **Mechanical failures:** the theory behind automated trading makes it seem simple: set up the software, program the rules and watch it trade. In reality, however, automated trading is a sophisticated method of trading, yet not infallible.
- ▶ **Monitoring:** although it would be great to turn on the computer and leave for the day, automated trading systems do require monitoring. This is due to the potential for mechanical failures, such as connectivity issues, power losses or computer crashes.
- ▶ **Over-optimization:** traders who employ backtesting techniques can create systems that look great on paper and perform terribly in a live market.

Which are the main approaches used?

- ▶ **Fundamental analysis** focuses on the prospects for governments, companies and hard assets.
- ▶ **Technical analysis** is the study of prices and other data to determine trading patterns.
- ▶ **Quantitative analysis** relies on number crunching. Financial and trading statistics and other data are collected and run through mathematical formula programmed into computers.

PhD Project

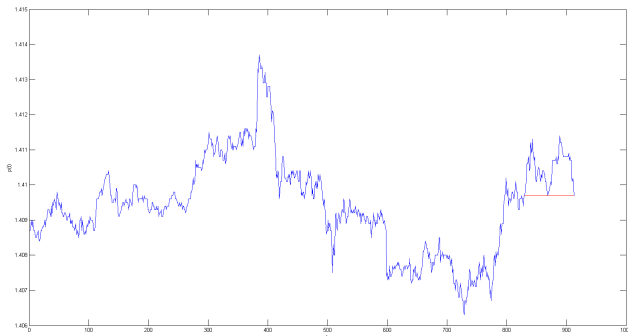
Let P_1, \dots, P_N be N technical patterns.

We want to develop an automatic trading system which can identify patterns online and automatically trade on markets.

The main steps are as follow:

1. developing recognition algorithm;
2. backtesting trading rules;
3. real time trading.

Step 1: pattern recognition



Problem definition: online detection of predefined patterns.

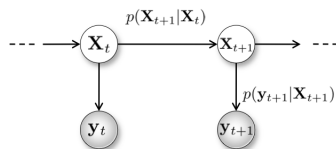
Hidden Markov Model

A *Hidden Markov Model* (HMM) is a stochastic process $\{(X_t, Y_t)\}_{t=1,2,\dots}$ with the following properties

$$p(X_t = x_t | X_{t-1} = x_{t-1}, \dots, X_1 = x_1) = p(X_t = x_t | X_{t-1} = x_{t-1})$$

$$p(Y_t = y_t | X_t = x_t, Y_{t-1} = y_{t-1}, \dots, X_1 = x_1, Y_1 = y_1) = p(Y_t = y_t | X_t = x_t).$$

In particular, $\{X_t\}_{t=1,2,\dots}$ is a *Markov Chain* (MC).



HMM and pattern recognition

Let P_1, \dots, P_N be N pattern.

We build N HMMS $\lambda_1, \dots, \lambda_N$ using the EM algorithm and Genetic Algorithm. Each HMM describes a pattern.

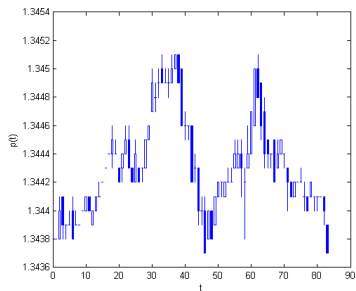
We also estimate a threshold model λ_T , such that

$$p(P_i; \lambda_i) > p(P_i; \lambda_S), \forall i = 1, \dots, N.$$

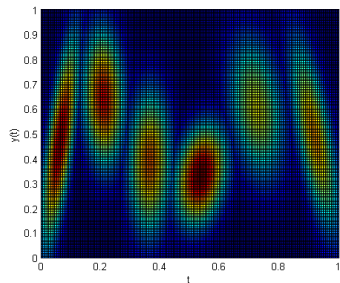
Given an observation O of a possible pattern, we say that O belongs to the class $\hat{\lambda}(O)$ if

$$\hat{\lambda}(O) = \operatorname{argmax}_{\lambda \in \{\lambda_1, \dots, \lambda_N, \lambda_S\}} p(O|\lambda).$$

In particular, if $\hat{\lambda}(O) = \lambda_T$ the observation is not a pattern we are looking for.



(a) *Double maximum.*



(b) *HMM of double maximum.*

Our recognition software

The software we have developed can recognize eleven different patterns. All algorithms can detect **real time** patterns and does **not depend on financial assets and time frame** (temporal unit).