Introducing ATOM

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1 Motivation

Elements of Context

In recent years, Artificial Intelligence systems have received an increasing amount of academic interest in Economics and Finance. Among these works, Artificial Stock Markets (ASM) have particularly benefited from the agent based approach and from the Multi-Agent philosophy.

The application fields for Agents-based modelling and simulations in Finance appears extremely promising. For example, one can study the impact of a Tobins tax on the financial system, or one can develop new stress tests for assessing financial resilience to economic shocks or to develop new automatic trading techniques. Implementing realistic simulations of complex financial dynamics using both artificial intelligence, distributed agents and realistic market algorithms gives the researcher a powerful tool for understanding stylized facts and for experimenting various regulations in a controlled, riskless experimental environment.

MAS offer a new framework for investigating questions that have been tackled for years with tools grounded on non realistic assumptions. On the contrary, ASM are grounded on an individual-based approach with local interactions, distributed knowledge and resources, heterogeneous environments, agent autonomy, artificial intelligence, speech acts, discrete scheduling and simulation, all things that cannot be used or done in traditional, aggregate models.

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A typical example of the MAS adequacy of artificial markets for tackling difficult questions in finance is proposed in [7]. In this paper, the authors build a decision support system designed to help (or eventually to control) a broker in executing a set of orders and in respecting *"equitable principle of trade"* for his clients. The solution proposed in this article consists in evaluating the execution of a set of orders with a social welfare notion (based on the wealth of the agents representing the the brokers' clients) after simulating the impact of various hypothesis of orders execution. It is argued that without a MAS system, it could not be possible to solve this problem.

The core tool used in this research is the "Artificial Trading Open Market" (ATOM) developed at Lille 1 University. ATOM is one of these ASM evoked previously. It is platform independent, and fully flexible. ATOM is able to generate, play or replay order flows (from the real world or generated artificially) extremely quickly. It can also be used to design experiments mixing human beings and artificial traders. ATOM is used, among others, for research in Portfolio Management, Algorithmic Trading or Risk Management.

Last but not least, ATOM is a smart and very nice tool to learn market finance : it can be used as an experimental software in the classroom or as a simulator for finance newbies. It can then allows distributed simulations with many computers interacting through a network as well as local-host system.

Main purpose

ATOM wants to clone the main features of the Euronext-NYSE stock exchange microstructure. It aims at matching orders sent by virtual traders to determine quotations and prices. These market values are ruled by a negotiation system between sellers and buyers based on an asynchronous, double auction mechanism structured in an order book. Thus ATOM is build to generate, play or replay order flows.

These order flows can indifferently be the outcome of more or less sophisticated artificial traders, or of human beings. In this last case, ATOM can use *"on the fly"* orders, exploiting its ability at mixing artificial and/or real traders. It can also merely replay orders generated during a trading day by real world investors. This means that bankers can test their algorithmic-trading strategies using historical data without modifying the existing price series or back test the impact of their trading-agents in totally new price motions or market regimes generated by artificial traders.

ATOM uses two kind of scheduling systems. One implements fairness for all the agents; this is crucial for reproducibility. The second one uses several execution flows and allows notably human-machine interaction with "human in the loop".

Due to this need of interaction among various kind of Agents, ATOM had to allow distributed simulations with many computers interacting through a network as well as local-host, extremely fast simulations.

One of the main advantages of ATOM consists in its modularity. This means that it can be viewed as a system where three components interact: i) Agents, and their behaviours, ii) Markets defined in terms of microstructure and iii) the Arti-

ficial Economic World (including an information engine and, potentially, several economic institutions such as banks, brokers, dealers...). The two first components can be used independently or together. Depending upon the researcher targets, the artificial economic world can be plugged or not in the simulations.
An other advantage of ATOM is that it overcomes many of the other artificial market platforms limits, for example in allowing simultaneously realistic intraday simulations (with an opening and a closing fixing session) and long-range multi-days experiments in a multi-asset framework.

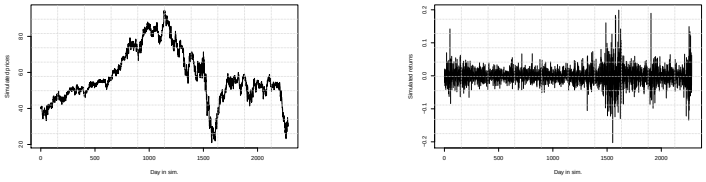
2 Demonstration

We illustrate the power of ATOM as a multi-agent Artificial Stock Market along two lines : the first one shows how it can be used for scientific or technological research, the other how ATOM can fit in training sessions (for example in an academic Finance program).

Step 1 : playing with Zero or Near zero Intelligence Traders.

i) ATOM is fast. For example it can replay a real world order flow received by Euronext-NYSE central order book for a given stock in a few seconds (see for example [6]). With relatively basic agents' behaviours, ATOM can execute more than 400.000 orders in less than 4 seconds. Used as a test-tube, it is able to execute a simulation using 1000 agents running during 1000 days, each of then constituted by 1000 rounds of talk (thus 1 billion orders sent) in less than one hour. Compared to a High Frequency Trading architecture, it is able to execute one order in less that 4 milliseconds.

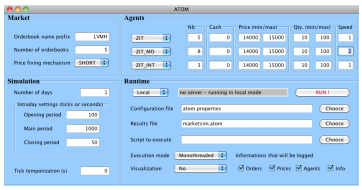
ii) During the demonstration, we simulate a market populated with 100 agents (ZIT, see for a description of the behaviour [6]) on 10 assets during 10 days. We show what can be done in term of analysis with these data (study of prices, returns on a daily and intra-day basis, volumes of trade and eventually the tracking of an agent's wealth over time). Then we will show that it is possible to re-execute exactly the log file obtained, recreating automatically all the orderbooks and all the agents.



(a) prices (b) Returns

Fig. 1 Simulated series, one series / 10

Step 2 : Pedagogical use of ATOM We show how to use ATOM in a pedagogical perspective or in a classroom. For that purpose, we run a powerful applet built on ATOM, and a web interface which allows the user to create an experimental market for his students for example.



(a) ATOM in the classroom

(b) ATOM SeriousGame, typical results

Fig. 2 A pedagogical tool

In this configuration, ATOM can be used for a progressive learning of market microstructure : for example, the outcome of different orders can be isolated in the book as well as the results of specific order execution strategies. In mixing artificial agents and human beings, ATOM offers an exiting, dynamic environment replicating the heterogeneity and the pace at which a real market operates, with the additional opportunity to maintain this complexity to a reasonable level for learners.

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