Research Statement Interest

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January 2016

Throughout my studies, from the very beginning of my time at the university continuing through to my actual PhD, I always managed to follow an interdisciplinary path, mixing computer sciences with evolutionary biology, cognitive sciences, philosophy of science and during the last year, history, economic and archeology.

This interest in multi-disciplinary start long before entering the university, when young I look this amazing ability of numeric artifacts built by humans to exhibit 'life-like' or 'human-like' behaviors, and those incredible 'natural' behaviors, so complex and well adapted. I quickly became determined to find a way to understand both entities: the living ones and their artificial counterparts. Since then all the courses I chose, all the schools I decided to attended, and all other choices I made were in pursuit of obtaining a better understanding of it.

This genuine inquiry quickly evolved into a concrete research quest: I started to wander what were the links between human production (language, social organization, computer abstraction) and natural systems driven by Darwinian evolution. How they seem sometimes so similar? Why we can use artificial tools to understand the complexity of natural systems and why we can use the highly adapted design of natural systems to refine our artificial tools? How such systems can, based on simple rule and without supervision, diversify, adapt and change their environment as well as they change themselves?

To answer those questions I did a first Master Degree in Natural & Artificial Cognition in which I focused on the study of the evolution of division of labor in swarm of autonomous agents. The main idea was to explore what are the properties of the reproductive network that permit the emergence such division of labor. Those work are still ongoing and will soon be published. In parallel I studied the same kind of mechanisms but in simulated 'cognitive' agents designed with psychologists. The idea here was to explore what kind of environmental conditions allow subpopulation of cooperative agents to co-exist with populations of selfish individual. This work has been published few months ago [3].

In both case the results I found were valuable as themselves for me and provided a new understanding about crucial evolutionary processes in totally different contexts. But to convince people that this knowledge could be applied to real world entities and that it was valuable for the understanding of the world in general was not as straightforward. I realize that if I wanted myself to be able to produce meaningful, useful and concrete research projects and moreover if I wanted to be able to make the link between such projects and what more 'traditional' scientists were doing, I would need a deep understanding of the tool I use, the subject I study and the link between them.

That decided me to engage myself in another Master Degree in History and Philosophy of Science. My work then focused on exploring what is the nature of evolutionary processes and how we can study them using computers. It allowed me to learn precisely the history and the construction of Evolutionary Biology since Darwin and to dig deeper in the philosophical debates that occurred throughout this history. I took also this opportunity to diversify the nature of the systems I wanted to study: I created the LaReMI Junior lab (http://en.laremi.net/), financially supported by the Ecole Normal Superieur (Lyon France) with the idea of applying similar approach (simulation coupled with simple cognitive experiments) to study the evolution of music melodies. It was my first contact with what is called 'cultural evolution', but moreover it allowed us to organize an international workshop on the topic in Lyon (http://en.laremi.net/actvity/meeting[1]) and to present our approach to the community in Lisbon [1].

After those two complementary Masters, I pursued the exploration of such questions in the scope of my actual PhD I started last year. The idea here is still to use simulation to try to understand the conditions of evolution of particular dynamics in a decentralized system. This time I choose to study the evolution of cultural and economic network during the

[1] Regarding to the auto-hosting solution we adopt for our server, the loading of those pages could take time

Roman Empire. An historical question about a human activity in a project [2] involving historians, archaeologists as well as database specialists. My work focus on trying to understand the conditions of the emergence of a decentralized market. The main goal is to provide tools to measure if such conditions were satisfied during the Roman period and if not, what kind of economy we should expect to find. To do so I developed a simple cultural evolution simulation where cultural transmission mechanisms lead to economical changes, that in turn modify the cultural dynamics. Right now I am exploring what kind of properties the cultural network need to exhibit in order that a stable decentralized economy evolved and I already presented the computational framework at the Winter Simulation Conference [2] and I will present the first results we obtains with the networks in Oslo.

Those past 4 years and my actual research project can be summarized as the exploration of how systems made up of huge number of entities (homogeneous or not), highly decentralized and mostly unsupervised, can evolved powerful adaptive properties such as division of labor, cooperation, specialization and learning whatever the nature of such entities. Thanks to my master in Philosophy of Science I also developed a deep concern about the epistemological relevance of what I am doing. Computer Simulation and Complex Systems Analysis are powerful tools but they could quickly mislead the research and bring the researcher to nonsense and useless explorations. Moreover, the questions raised by such approach quickly go behind the simple empiric inquisition and require skills that allow to rethink and redefine the traditional epistemic baggage into framework far from the ones scientists are use to work in.

In every projects I worked I saw how mature such approach is getting. Trying to understand decentralized and unsupervised evolving system *per se* is providing knowledge in a wide range of different area. It is not anymore a marginal object of distraction for curious scientist. With new generation of physicists, biologists, sociologists, economists and even historians who learn such methods, concrete hypotheses are formulated and can be tested. With computer and program always more powerful, and with scientist like me with a strong transdisciplinary background, a high expertise and able to make the link between the questions, the methods and the results, new discovery can be made about topic that were even unthinkable before.

This gives us a wide open area of research where a lot remains to do. I will continue to explore it. Among other things, I will continue to explore the networks' properties that allow systems to evolve properties such as cooperation, division of labor, specialization...but I want to understand how such networks can evolve. Another huge track of research I want to pursue is to study in what extend the evolution of those properties depend on the abilities of the system to interact with its environment (using developmental mechanism, simple learning, cultural transmission,...).

In any case my main concern is to tighten the link between what I am doing, the empirical data and the scientists working to try to extract meanings from those data. To do so I will continue to work with people from different field but with concrete, real and complex case study. Because I think that the most valuable and beautiful striking knowledge don't lie in computational simulation we can do or in the mathematical model we extract from it, neither in the simple analysis of the raw data and the description of such analysis, but emerge from the well articulation of both side.

References

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[3] E. Zibetti, S. Carrignon, and N. Bredeche. ACACIA-ES: an agent-based modeling and simulation tool for investigating social behaviors in resource-limited two-dimensional environments. *Mind & Society*, pages 1–22, 2015.

[2] ERC grant EPNET: www.roman-ep.net