The importance of social simulations

The search for knowledge is intrinsic to human beings. It's in our DNA. The curiosity about what surrounds us has been the engine that propelled us throughout history, helping us survive. Because without knowledge, there is no survival.

However, we have often been more willing to look outside than inside, and we have left little time to understand ourselves and deepen into the processes that rule our behavior.

As social beings, the way we take decisions and act on them is strongly influenced by our interactions and the relationship with our environment, either by adapting to or modifying it. Societies are extremely complex systems, and in order to understand their behavior it's not enough to study isolated individuals.

Many disciplines have taken an interest in the analysis and study of the evolution of human behavior, from history and archaeology to biology, anthropology, and ecology. Knowing the origin of the first civilizations and why they stabilized or collapsed allows us to better understand current societies and find solutions to future problems. However, studying the distant past is complicated because we do not always have all the data we need. Archeologists for instance have traditionally worked on unstable terrain, fiercely trying to analyze often disconnected pieces of information. Thus, it is difficult to elaborate an exhaustive theory of human behavior, and even more so if we take into account that many of the above cited disciplines have developed with hardly any collaboration between them.

For all of this it is important to find new tools to help us join efforts and increase our exploratory and explicative potential. Computer simulations are that tool. Thanks to them, we can mix in the same environment social sciences with mathematics and other, more recent, research fields such as genetics, engineering, or informatics. They allow us to develop a interdisciplinar methodological framework capable of modeling and simulating primitive societies, and thus analyze their decision making processes and the mutual influence relationship with their environment.

However, as each simulation is unique and unrepeatable, it is important to make a large number of them in order to obtain statistically meaningful insights. If each simulation is complex, this means that we cannot make these studies in any computer. Instead, we need the large computing capabilities of a supercomputer like Marenostrum, in Barcelona.

In summary, social simulations allow us to understand better, which is key to overthrow the old prejudices that prevent us from deepening into the processes that define the different historical periods and their random elements.

Inside this context the project Simulpast was born, attempting to become a platform to develop new research perspectives in social sciences, and improve the study of human behavior.

What is the Simulpast project?

<u>Transdisciplinar</u>
The project encompasses 11 groups with researchers from different fields. From the start, the goal of the project was to create hybrid research profiles that allow us to overcome the existing differences between distant areas of knowledge. In this way, the project aims at providing a holistic approach to the analysis of historical, social, and ecological dynamics.

<u>Innovator</u>
The project aims at advancing the state of the art in social sciences by introducing artificial intelligence simulations together with high performance computing (aka supercomputing). For this, the project uses and develops a tool that makes maximally efficient use of the Marenostrum supercomputer. The simulation code is called *Pandora*.

Pandora is an agent based modelling tool designed to run complex simulation models in a high performance environment. The agents represent individuals or groups of people (a family in the case of Simulados) with a complex artificial intelligence algorithm that gives them power to make their own choices and act upon them, thereby interacting between them and with the environment in a totally autonomous way. Pandora is able to simulate millions of agents in large and detailed terrains.

The study cases
Simulpast is divided into 7 study cases, which align with three general lines of research.

Line 1: Socio-ecologic dynamics and strategies for resource exploitation
This line includes the study cases that research the reciprocity between geographic/environmental contexts and the socio-ecolgial dynamics and strategies implied in the mechanisms of resilience and change.

Case 1 (shown in *Simulados*): <u>*Persistence of hunter-gatherers in the north of Gujarat (India).*</u>
This region of India has a strong seasonality and one of the most unpredictable climates in the world. The main goal is to build an agent based model (ABM), through which we can study the management of resources and the decision making process of hunter-gatherer groups that inhabited the region between 10000 BC and 2000 BC. We are interested in analyzing their capacity for resilience to the extreme variability of the environment, as well as their interaction with agro-pastoral groups.

Case 5: <u>*Construction of oasis in Central Asia.*</u>
Central Asia is a region in which many different pre-industrial production methods have coexisted for thousands of years. This coexistence is called an "oasis", and spans irrigated land as well as desertic areas and nearby mountains. Considering oasis as ecosystems, the study case is focused towards the study of economic and socio-politic interaction in such ecosystems, in particular between groups with different patterns of subsistence (irrigation agriculture and nomad pastors).

Line 2: Emergence of properties and social dynamics
This line puts together projects directed towards the exploration of ethnicity and social cooperation questions.

Case 2: *Appearance of ethnicity in hunter-gatherer societies in Patagonia (South America).*
Through the ethnographic study of diverse human groups of the region (Mapuche, Günu-na-künne, Tehuelche, Selknam, Haush, Chono, Kawésqar, Yámana, etc.), this study case aims to examine different hypotheses about the formation of cultures, the patterns of influence between the groups, and the different emergent behaviors.

Case 3: *Social cooperation in late hunter-gatherer societies in Tierra del Fuego (Argentina)*
This study case is devoted to the evolution of cooperative behavior given through social aggregation events in the Yámana society. Ethnographic sources inform about the existence of periodic aggregations due to the sporadic accumulation of large amounts of resources (a whale washed up in the beach, for example). Through smoke signals, the finding was made public and, during the event, the production, distribution, and consumption were done in a collective manner while other social activities took place.

Line 3: Diffusion and cultural transmission.
In this line we include the projects focused towards transmission and diffusion of technology and knowledge.

Case 4: *Exchange network dynamics in early societies in the near east (Syria).*
This study aims to examine the exchange networks and the circulation of obsidian as a source material in the early neolithic period in the near east. We start from a SIG database with information on the archaeological sites, their corresponding chronologies, and the amount of obsidian found, as well as their source.

Case 6: *Origin and expansion of agriculture in prehistoric Europe.*
This case is centered on the study of spatial dynamics in the early Neolithic in the Iberic peninsula. We examine the introduction and expansion of Neolithic in the peninsula, trying to test the hypothesis that this introduction was done through the mediterranean coast and north Africa.

Case 7: *Dynamics of social interaction and adoption of innovation in prehistoric Europe.*
This case study aims to make a geostatistical analysis through computational simulation, using near 1500 carbon dated samples from archaeological contexts coming from Italy, France, Germany, and the Iberian Peninsula, with the goal of studying the probable causes (migration, social emulation, or cultural transmission) of the economic, social, and cultural changes that happened at the transition from the bronze to the iron ages.