# Ergonomic Approach for Human Movement, Its Complexity Nature and Aspects for Its Simulation

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## 1 Context

Many people spend most of their lives inside built environments. Our interaction with these environments greatly influences our safety and quality of life. Within the various aspects involved in the interaction with these environments, those related to human movement play a prominent importance, since we move and change continuously from environments, even in the same building or system. Thus, environments must be organized, having appropriate design and layout, to facilitate the movements that will occur, and to minimize the possibility of accidents.

Due to the importance, there are various of minimum normative and legal criteria to be considered in the organization and design of buildings, urban spaces and other environments to be occupied. However, the normative specifications cover only some characteristics. I would be important to go deeper in the study of the environments. Computational models can help in this evaluation to promote improvements in environments design and use.

Even environments that do not normally have high population densities can become dangerous in situations of escape or panic, due to the possibility of people concentration searching for few exit routes and to the occurrence of passage in no free spaces (doors, openings, stairs, walls, curves) that can cause delays and collisions during the movement.

In the last years, the study and modeling of systems with complex behaviors has leveraged large interests of researchers from diverse fields of knowledge, such as physics, mathematics, engineering, computing, medicine, sociology, or marketing. In the ergonomics field, the term complexity has too been widely used and discussed [VIDAL et al., 2002; GRANT, 2002; VASONCELOS et al., 2008; VIDAL et al., 2009; DANIELLOU et al., 2010; GONZÁLES & SAURIN, 2013]. However, due to the still

relatively recent nature of this modus of application of the term complexity, we have the existence of a myriad of conceptualizations for complexity, making it necessary a prior definition for this term before advancing in the matter.

In the focus here, a complex (or complex behavior) system will be strictly considered as having interactive elements and exhibiting emerging properties that do not result from the existence of a central controller [BOCCARA, 2004]. In this context, emergent properties are characteristics that hatch as a result of the interaction of the elements of the system itself.

Research in the ergonomics involving complex phenomena are usually focused on so-called sophisticated tasks. In this work, the simple human movement, despite its apparent triviality, is presented as being, in itself, rich in the emergence of complex behaviors. This is an important characteristic to be understood, since complexity can both promote the improvement of the environment and also result in serious accidents.

Thus, the objectives of the present work are: to present the process of human movement in an environment built as a complex ergonomic system; to exemplify several ergonomic characteristics that can be used as beacons of computational models to simulate the process of human movement; and, to propose guidelines for the development of a suitable computational modeling for that purpose.

Several parameters or factors can be considered, including physical, cognitive and organizational ergonomics, necessary to synthesize a suitable modeling of human movement by agents, such as: the representation of the physical environment and its preferential routes; the representation of human bodies and their levels of stress; the reaction time in emergencies; the expected velocity of movements; the effect of comfort zones; the inertia effect; visual and sound signaling; the possibility of falls and accidents; the type and quality of the floor; organizational factors; among others.

## 2 Method

A comprehensive bibliographical research was conducted in order to identify the occurrence of complex phenomena in simple human movement, even in very simple systems. Some photographic records were obtained to corroborate these phenomena. Some ergonomic parameters potentially relevant to the development of a computational model for the simulation of human movement were also identified and discussed, and how schematically these parameters relate to each other, allowing for the occurrence of complex phenomena.

## 3 Results

Specifically in human movement, there are many examples of complex behaviors and their effects (STILL, 2000; HELBING et al., 2000; GOLDSTONE; ROBERTS, 2006; SCHADSCHNEIDER et al., 2009). Among the most important, the use of movement routes that were not foreseen or even prohibited must be cited. It is not uncommon to find in some place, despite the existence of an appropriated route suitable for human movement, the formation of trails that can be perceived by the absence of vegetation that should occur there. These tracks are formed by the constant passage of people along this path not idealized to function as a human passageway. These alternative routes arise for different reasons, being the most common the search for reduction of the distance to be traveled and, for environments of greater population density, the maintenance of the normal velocity of movement. Another reason for the occurrence of trails is the lack of ergonomic adequacy of the main route of travel.

In agent-based modeling, each simulated person will have their characteristics incorporated, and will interact with the environment, perceiving the environment and their own choices of routes and ways of movement. This form of modeling does not force any of the simulated people to make decisions. The decision-making process is individual and private, and from this individual behavior the collective and complex effects that occur in a real movement will be obtained through self-organization of the system and its local relationships. Such an agent-based ergonomic modeling proposition has already been implemented computationally with promising results (BRAGA et al., 2014), including the observation of some complexity, but still in a limited fashion.

## 4 Conclusions

In this work, it was demonstrated that human movement, even by itself, is already included in an ergonomic system, where physical, organizational, cognitive and environmental aspects are widely present. It has also been shown that, although human movement is apparently simple, the complexity, or the emergence of phenomena, plays a very important role in its development. The agent-based modeling, elaborated in an ergonomically situated way, appears to be a powerful computational tool for simulating human movement in a context of complexity, where local relations can generate self- organization. In future works, it is intended to increase the depth and quantity of properties involved and their interrelationships.

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