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# A hybrid approach with agent-based simulation and clustering for sociograms

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ABSTRACT

In the last years, some features of sociograms have proven to be strongly related to the performance of groups. However, the prediction of sociograms according to the features of individuals is still an open issue. In particular, the current approach presents a hybrid approach between agent-based simulation and clustering for simulating sociograms according to the psychological features of their members. This approach performs the clustering extracting certain types of individuals regarding their psychological characteristics, from training data. New people can then be associated with one of the types in order to run a sociogram simulation. This approach has been implemented with the tool called CLUS-SOCI (an agent-based and CLUStering tool for simulating SOCIograms). The current approach has been experienced with real data from four different secondary schools, with 38 real sociograms involving 714 students. Two thirds of these data were used for training the tool, while the remaining third was used for validating it. In the validation data, the resulting simulated sociograms were similar to the real ones in terms of cohesion, coherence of reciprocal relations and intensity, according to the binomial test with the correction of Bonferroni.

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## 1. Introduction

Establishing positive social relationships is thought to be a crucial aspect for well-being. Thus, for example, the famous Maslow's Hierarchy of Human Needs [34] includes "the love needs", described as "hunger for affectionate relations with people in general, namely, for a place in their group", as fundamental need for achieving self-realization. A more modern theory based on basic psychological needs, self-determination theory [43], proposes the need of social contact, referred as "relatedness need", as one of the nutrients that is essential for ongoing personal growth, integrity and psychological health.

A frequent instrument used to measure social relationships is the sociometric techniques developed by Moreno [35]. Sociometric techniques identify types of relationships among peers, formulated in terms of attraction and rejection. It is acknowledged that the degree of acceptance and rejection among peers at school is key to psychosocial adjustment and academic success in adolescence [6] and other stages such as childhood [26]. Popular adolescents, who are accepted by the majority of their peers, are characterized for their interpersonal abilities, their empathy for others, and their willingness to

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cooperate non-aggressively [10]. In addition, peer acceptance is positively associated with social prominence [51]. On the contrary, rejected adolescents are perceived as unpleasant and are less liked [6]. Besides, they show more psychosomatic symptoms and are affected by more psychiatric disorders [29]. They have more conflictual relationships with other classmates and teachers, being more frequently involved in disruptive and aggressive behaviors that lead to the violation of institutional rules [37]. As a matter of fact, conflictual relationships have been proposed as the cause of being rejected by their peers [22].

Sociograms represent the social relations within a group. In sociograms, the cohesion and structures of relations have been previously proven to be related with the performance of the group, as stated for example in [24]. Specifically in education, Yu et al. [49] improve academic performance of student groups by considering student profiles and different levels of academic performance when making the groups. Thus, sociograms of student groups considering student profiles may be relevant when taking academic performance into account. In addition, simulation is useful for predicting emergent behaviors of groups of individuals [45]. In this manner, in some cases one can apply or prepare the necessary actions beforehand. Nevertheless, to the best of authors' knowledge, there is not any simulator about student sociograms. In this context, the current work presents a novel hybrid approach with an agent-based simulator (ABS) of sociograms that uses clustering for classifying students.

The current work selects developing an ABS, because in the literature [33] this kind of simulators has been proven to be especially useful when simulating environments with several autonomous individuals that make their decisions and establish their social relations. The current approach selects clustering as the mechanism for classifying students, as clustering has already proven to be useful when classifying students or other features related to them, as one can observe in [46].

The current work presents a tool that implements the present approach. This tool is called CLUS-SOCI (an agent-based and CLUStering tool for simulating SOCIograms). CLUS-SOCI is prepared to be trained with certain known input data, so that then it can be applied to simulate certain unknown data. CLUS-SOCI is mainly composed of three modules. The first module has been named the clustering module. This module receives input from training data, i.e. existing real and known sociograms of certain individuals with specific psychological features. This module is responsible for clustering the existing individuals in certain clusters (also referred as types from this point forward) according to their psychological features, and relating these clusters with certain social behavioral information. Second, the management module allows practitioners (1) to load and learn these types, (2) to classify any individual into one of the learned types according to their psychological features, (3) show and measure any sociogram, and (4) to invoke the ABS of the remaining module. The third module is the ABS for simulating sociograms for a group of individuals classified with the corresponding previous step.

The current approach and its CLUS-SOCI tool have been experienced with student sociograms from four different secondary schools of the Aragón region of Spain. The data involve 714 students with their psychological features extracted with the corresponding tests. These students constitute 38 groups with their corresponding sociograms. Approximately, two thirds of these data were used as training data, and the remaining data were used for validating the current approach. The results showed that the simulated sociograms are similar to the real ones for some characteristics according to the corresponding statistical test.

The current work extends our previous work about the FTS-SOCI tool [20]. The most relevant improvements are (a) the clustering process for obtaining the student types in the training phase, (b) the classification of students according to their psychological features, and (c) the enhancement of experiments, based on 38 real sociograms instead of two, and considering four sociometrics instead of two.

The remaining of the article is organized as follows. The next section analyzes the related works highlighting the gaps of the literature that are covered with the current approach. Section 3 presents some psychological instruments as background of the presented approach. Section 4 introduces the current hybrid approach describing its modules. Section 5 presents the experimentation including the training and the validation phases. Finally, Section 6 depicts the conclusions of the current work, and mentions some future lines of research.

## 2. Related work

The current work presents an ABS approach for simulating sociograms based on the psychological features of the individuals. It applies a clustering technique for detecting individual profiles, which are the base for training the ABS. Hence, this work organizes the discussion of related works in three main blocks: (1) sociology simulations, (2) simulations with clustering, (3) multi-agent systems (MASs) with clustering, and (4) social network algorithms. Since the current work is implemented with an ABS, most analyzed works fall into this category.

### *2.1. Sociology simulations*

ABSs have been widely applied to simulate sociology experiments. To begin with, Macy and Willer [33] present a survey about the modeling of ABSs for being applied in sociology. They present the main features that make MASs especially useful for simulating sociology aspects. The construction of the behaviors is performed with a bottom-up approach, in which the agents simulate individual behaviors within a society. These systems make it possible to simulate emergent behaviors from the interactions of individuals. They also mention some aspects such us collaboration between peers and whether these trust each other. Their survey introduces several works that relate ABS modeling with sociology.

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