Crowds and Spontaneous Collaboration

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Abstract - *Study of Crowd dynamics has had significant overlaps with models of biological swarms. Understanding and directing human crowds have also been of long-standing interest. In this paper, we describe a few basic cognitive processes that account for life cycle of typical human crowds. Individuals change their behavior with stimulants that attract a crowd. A crowd remains in place and behaves as a collective unit as long as stimulants persist. Once original stimulants cease or others emerge, the crowd disperses and individuals return to their individualistic behaviors. Although crowd phenomenon is commonly observed in natural settings there are no previous explanations for it. Our model stride lays the groundwork for further modeling of common human crowds.*

Keywords: Human crowd model, multiagent simulation

1 Introduction

At very high autonomy levels that are needed for machine to machine collaboration in mission critical operations of the DoD, collaboration among entities of a group such as a battalion can be seen to be in the form of shared world views. This is the perspective that entities share ordinary as well as mental states with their peers through networked medium such as a social network. Decisions and actions taken by an individual affect others. The context of a given domain affects others with varying impacts and speeds. For instance, in a typical legal setting, the time horizon of interest can be measured in days to weeks whereas in an air traffic control the time span is in seconds to a minute. In sporting teams or swarm flight formation, the time span is yet smaller. In a first responder or gunship control the time span of interest descends below milliseconds. At the latter settings, there is no time for effective human level communication or much less argumentation involving humans. For brevity, we'll dub this context Spontaneous collaboration (SC). There are natural limitations for a social network providing a shared world view for SC. Groups in a social network cannot behave as if they had a single mind that is often required for SC. Despite requiring biological conspecificity, a crowd cannot be properly modeled as a social network since individuals still operate with independent minds. Cognitively, Marvin Minsky likened the human mind to a society of agents [12]. However, the reciprocal of likening a group/society cognitive unit to a single mind is not feasible. Life cycle of a group mind is fascinating and discussed in this paper. At some point individuals yield their own reasoning to the group for a marginal gain from the collective advantage as in sheep behavior [5]. The state is maintained as long as individuals draw benefit from it. An individual departs from the pack when it senses a loss of original advantage. Ed Hutchins of UCSD has studied the psychology of group cognitive units in primates as well as among the Naval aircraft crew [7]. He initiated the subfield of distributed cognition in psychology with implications for social cognition. Drawing inspiration from social cognition, we believe that the cognitive processes responsible for initiating cognitive cohesion among individuals in a close knit group to be the foundations of crowd cognition. Homophily is an example of psychological attraction to be with others [8].

Numerous studies have been made trying to understand the collective behavior and the crowd formation of animals. Animal crowds have different names like swarms, flocks, schools, colonies and etc, depending on the specie. Researches try to understand why animal crowd and also how the animals act collectively. Numerous models have been designed to represent these crowds, models that are based on the size and the density of the crowd, which are interrelated according to Niwa's model, that the mean group size will strictly increase with population density [19].

Homo-sapiens behave collectively as well for all the same reasons as the animals do, but also for other reasons; due to our social intelligence and our ability to create crowds and groups, not only because of our natural instincts, but also willingly and purposively. This volitional behavior is creating

masses of people that have similar behavior and collective intelligence-- these masses are called crowds of people, or mass, or mob, etc, depending on the meaning and the purpose of the gathering.

The impetus that propelled ancient Greeks, as philosophers, to explore crowds and mobs were to understand and harness the power that crowds possess. They distinguished mobs, which were called ochlos (Greek: οχλος), from crowds due to the reason that mobs were easy to manipulate, easy to sway and persuade. They created the term ochlocracy that means government by a mass of people, and they discriminate ochlocracy as a bad form of government. They also created democracy, a government type that is still popular today. Ancient Greeks understood that by studying crowd behavior and crowd psychology they could find ways to manipulate them and lead them to a desired conclusion.

One of the original founders of crowd research is Gustave Le Bon, who defined crowd in his book [10]. Le Bon's crowd is any gathering of people of whatever nationality, profession, or sex, and whatever be the chances that have brought them together [10]. He defined crowds as a gathering of anonymous people that tune to the lowest level of intelligence, present in the crowd, to achieve a certain goal. According to Reicher [15], to define a crowd is more complicated and more difficult that it seems. Since events in a crowd cannot be reduced to a generic set of behaviors, Reicher argues that all the classic accounts of crowds fail to give an accurate definition [15].

We define crowds as groups of people that are identified by their shared ideas, principles, emotional experiences, behavior, and goals in a share physical and social space. Therefore, crowds possess heterogeneous set of individuals and based on their shared ideas, principles, emotional experiences, behavior, and goals, form a cohesive units with homogeneous individuals.

There are models that have been created to represent a crowd of animals that are genetically identical and the crowd formation helps them to forage for food as in ants, to save energy as in ducks, to be secure as in fishes, and also to facilitate procreation. Other models consist of group of animals that are genetically unrelated and have similarly shaped group size and live in relatively homogeneous environments, like zebras and buffalos that have the same eating habits and can move at the same speed [19].

Many animals crowd using environmental homogeneity. Diverse physical features of the physical world could simply be attracting forces, rather than aggregation in response to other animals, for example water can attract heterogeneous animal species [19]. Another possibility is that the distribution of a predator species that crowd together is simply the existence of a potential prey [19].

A model can be designed detailed enough to represent a life cycle of crowd, from formation process to dispersion. In this paper we will outline salient factors that drive the behavior of individuals to the formation of a crowd and to collective intelligence. We will model a general sense of human and crowd behavior based on psychological and engineering principles, driven by external influences, environmental constraints, time, common and individual goals, and affects. Next we describe our generic model of human crowds.

2   Sketch of a Model

If we accept the research of Allport, then individuality is more prominent than crowd behavior: There is no psychology of groups separate from psychology of individuals. The individual in the crowd behaves just as he would behave alone [1]. It would be highly unlikely that any generic model could summarize every kind of crowd behavior or even a single one. The reason is that with any added individual to the crowd, the cohesive individuality in that crowd increases in an incalculable manner. However, based on our model, we can make the assumption that the growth of the complexity of a given model is increasing up to certain point. Next, we describe the crowd life cycle. We start with individuals and we track the process that turns them into a crowd. Also, we track the crowd members as they return to their state of individuality. Each stage is described by attributes that we will outline. Each stage can be further analyzed and then can be combined with the rest. Each stage, however, has its own steps therefore can be viewed as a sub-model on its own.

According to economists a rational man is an economic man and he is assumed to have knowledge on the relevant aspects of his environment, which if not absolutely complete, is at least impressively clear and voluminous. He is assumed also to have a well-organized and stable system of preference and a skill in computation that enables him to calculate, for the alternative courses of

action that are available, which of this will permit him to reach the highest attainable point on his preference scale [17].

According to Simon, we do not try to optimize our goal but satisfy our goal. Simon said that a rational individual has to be bounded by rationality that is unique human form in which a person arrives at a solution/goal that will satisfy his or her own needs even though it may not be computably perfect [17]. Simon's view is considered to be the correct one because in the real world the person does try to achieve the optimized strategy, but the person can be satisfied with close alternatives.

Crowd Formation is the most important part of the model for the reason that understanding the Crowd Formation leads us to the understanding of Crowd and Crowd Dispersion too. In this thesis, we consider Crowd Formation and Crowd Dispersion as an opposite process. By comprehending what motivates individuals to form a Crowd, we can find a way to satisfy their goal, which will lead to the dispersion of the Crowd.

Crowds are defined as groups of people that are distinct by their shared ideas, behavior and goals. These common attributes are what generate the formation of a Crowd in the first place. We suggest that each individual communicates with one's surrounding individuals (the ones in immediate physical proximity of himself). As we mentioned before, an individual is a rational entity and that results in a centralized conception of the self. So, we can apply the idea of this centrality of the individual in a social network by representing a single individual as a central vertex, in a social space [16]. According to Forsyth the core of a crowd is the groupings. The formation of the Crowd begins from certain stimuli that lead the individuals to recognize their common goal, behavior, feeling or affect as another person [2]. Therefore, the union of the common attributes of the different individuals can create an edge between two vertices on the graph that represents the relationship. (see Figure 1).

The more common attributes that two individuals share, the stronger relationship they possess, so in the graph the line that connect the two vertices will be thicker. Human beings have the tendency to reduce their physical and social need space and form relationships with people that are very similar to them, that is why, we can distinguish stronger relationships with vertices that are very close [8].
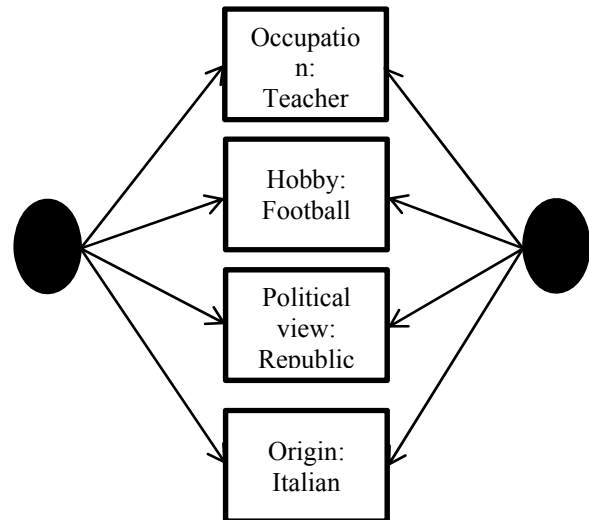

Figure 1. Possible Common attributes between individuals

When a group already exists and because of this existence, the behavior of the members of the group and the surrounding individuals is influenced. The self-categorization theory says that when people are members of a certain group, their behavior automatically changes to meet the group mentality of that group [20]. Moreover, according to this theory, for a particular member to categorize himself in a crowd, is driven by the social identity theory that involves three psychological processes.

1. Social Categorization: a way of thinking about the self and others that emphasizes membership in a group.
2. Social Identity: a portion of the self-concept that reflects the groups to which someone belongs.
3. Social Comparison: people compare their own group to any other group that seems relevant [14].

Crowd formation is simply the effort of an individual to categorize himself/herself in a group/different group, based on common attributes with the rest of the group members. The best categorization an individual can chose is the one that maximizes the similarities and minimizes the differences amongst the people in the same group/groups and also minimizes the similarities and maximizes the differences amongst the people in the out-group. This process is called meta-contrast ratio [14].

A Crowd Behavior is carefully regulated by already existing social Norms. Those Norms are providing limits for the behavior but also members

have to behave almost the same as their surrounding members in that Crowd [6]. The group behavior will result to collective judgments and collective choice. As people behave almost the same with their neighbors, they adapt even more extreme judgments than they intended [6]. Because of this behavior, most of the time, the decisions and preferences are conceptually distinct from the initial opinion of the individual [6].

Our model of the life cycle of a crowd consists of the following consecutive six stages. Stage 1 leads to 2 and on to 6 and back to 1 as such forming a complete cycle. The core of such a crowd exists between stages 2-5. This is an abstract model and describes the crowd in general. Crowds are ubiquitous and there are large class of crowd types with analyses that are outside our current scope. We envision that specific details for stages 2 and 5 that lead to formation and dispersion of a crowd can be divided into subcategories.

1. **Individual stage**: People reason autonomously and independent of others.
2. **Stimulation stage**: A group of people simulatenously experience commonality of feelings (e.g., fear) and reactions to external stimuli (e.g., flight to safety). Commonalities might include goals and behaviors (e.g., safety).
3. **Crowd Formation Stage**: The group of stimulated individuals behaves similarly as a collective unit.
4. **Crowd stage**: Once a crowd is formed in the previous stage, they remain a crowd and can be seen as a collective unit.
5. **Stimulation stage**: This stage is the opposite of stage 2 where the group experience lack of commonality of feelings and reactions to external stimuli. This divergence Commonalities might include differences in goals and behaviors.
6. **Dispersion stage**: At this stage the crowd begins to break apart its cohesiveness. This stage leads back to the individual stage.

Our model starts with individuals and we track the process that turns them into a crowd. Also, we track the crowd members as they return to their state of individuality. Each stage can be further analyzed and can be combined with the rest. The result is this model.

We have to understand the mind of a single individual first. The English dictionary presents a person as an individual human being with reference to his/her social relationship and behavioral patterns as conditioned by the culture (according to Dictionary.com). We will consider the individual as a rational entity. According to economists a rational man is an economic man and he is assumed to have knowledge on the relevant aspects of his environment, which if not absolutely complete, is at least impressively clear and voluminous [17]. He is assumed also to have a well-organized and stable system of preference and a skill in computation that enables him to calculate, for the alternative courses of action that are available, which of this will permit him to reach the highest attainable point on his preference scale [17].

Crowd formation is the most important part of the model for the reason that understanding the crowd formation leads us to the understanding of crowd and Crowd Dispersion as well. We consider crowd formation and crowd dispersion as opposite processes. By comprehending what motivates individuals to form a crowd, we can discover a way to satisfy their goal, which will lead to the dispersion of the crowd.

As we define in the introduction, crowd is a group of people that are defined by their shared ideas, behavior, goals etc. When an individual joins a crowd, the sentiments and ideas of that individual take a direction, the same direction as the rest of the crowd [3]. If we partially accept Le Bon's theory, the conscious personality vanishes and a collective mind is formed. With this in mind, we can characterize the crowd in few ways. Canetti proposed that crowd always wants to grow. For example, if an accident occurs, we can observe that the crowd around it will be getting bigger and bigger by the minute up to a certain point, which is specified by physical space and time. Secondly, within the crowd, there is a quality and thirdly the crowd loves density. The bubble space of each individual is almost disappearing. Fourth, the crowd needs a direction, for example a crowd of the people walking on the pavement in the same direction. Individually everyone has their own goal destination, but overall the crowd has a common goal: to reach that destination [3].

Le Bon and McDougalls suggested that a crowd is not simply a combination of individual acts, but rather a social behavior being guided by forces defined by the collection (Collective Consciousness or Group Mind) [10][11][21].

Moscovicis relied on Le Bon's and McDougall's theories, to suggest that collectiveness relies on shared images and shared ideas to form the basis of common sense. These shared images and shared ideas become the cognitive context within the crowd, which members follow to collective communication and coordinate their actions [13]; [21]. These cognitive contexts are called Norms, and in the case of crowds are called Social Norms. Social Norms are rules of behavior that synchronize our communication with others.

A Crowd Behavior is carefully regulated by already existing social Norms. Those Norms are providing limits for the behavior but also members have to behave almost the same as their surrounding members in that crowd [6]. The group behavior will result to collective judgments and collective choice. As people behave almost the same with their neighbors, they adapt even more extreme judgments than they intended to [6]. Because of this behavior, most of the time, the decisions and preferences are conceptually distinct from the initial opinion of the individual [6].

3   Implementations

In order to take a step toward validation we implemented a prototypical scenario that exemplifies our model. We will describe crowd formation that has been triggered by curiosity. Example of a crowd stimulant is when an incidence, like an accident or human fainting or something that can causes people to be curious about, occurs in the middle of the road, or in the university. We divide the problem into two stages.

In the first stage of the particular crowd formation, an instance crowd formation is observed. Moreover, the first crowd formation is triggered firstly, by the need of people to help others, so the goal in this case is to help, or by the need to satisfy their curiosity if we accept that crowds form on daily basis, at moments that are very tragic and shocking [9]. People have the need to help their fellowman because it feels good, because the one that helps, he or she has something to give and by that have a

feeling of being capable, "I can help, that means I am not worthless", and it is empowering, since it gives the helper a sense of control, [4]. The size of the this first group is depending on a lot of factors, like location of the accident, the appearance of the people that need the help, the culture and the abilities of the people that wants to offer help, and etc. Moreover, the size of the first crowd most of the times is very small. The collective behavior of these people that categorizing them as a crowd; is the willingness to help the person in need.
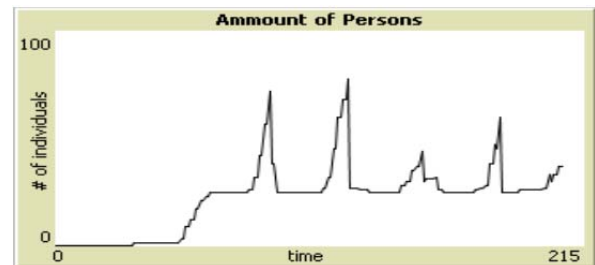

Figure 2. The density of people during the accident

The second reason that attracts the people up to that physical point is curiosity of the accident. Something, unexpected is changing in the picture of the normal world that people expected to live and to experience. That abnormal, and not dangerous for people, behavior that the particular person is presenting is sufficient to trigger the curiosity of the people that can have a visual with the incident, as it was explained earlier. Again, the size of this crowd is small, due to the reason that the people that experience the incident on the first hand are very limited. In the second stage of the crowd formation, crowd formation is being observed due to the necessity of the crowd to get bigger as Canetti mentions (Canetti, 1960). According to Canetti, the urge to crow is the first and supreme attribute of the crowd. People start streaming to that point, without even knowing what happened. A Canetti mentions that the movement of the people to that single point is being transmitted to others as well [3]. At this point someone can observe the collective behavior bonds (curiosity) that individuals are forming between them. The goal is to satisfy the curiosity and to understand the particular movement to a single reference point. At the second stage, the volume and the density of the crowd is much greater than in the first stage. Here crowd is formed in two waves, the first wave happens when people begin to arrive and try to join the rest of the crowd and the second stage is when the crowd renounces growth and puts a boundary to the number of people and the space that crowd is occupying. The second stage it can be compared to a vessel into which liquid is being

poured and the vessel is overflowed. The individuals that have satisfied their goal are leaving, and after a while are being replaced by others, see Figure 2.

4   Conclusion

The study of crowds is still at a very early stage. As the technology advances, we are going to be able to model and create agents that can mimic human beings and test the assumptions that researchers are making. Besides, with the help of the cameras, and Agent-based programs, we are able to create images that symbolize a basic pattern that a crowd creates. According to Keith Still [18], the patterns that each big crowd assumes, while it moves, are very identical and not random.

Acknowledgements

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