# From Individual Characters to Large Crowds: Augmenting the Believability of Open-World Games through Exploring Social Emotion in Pedestrian Groups

**Olivier Szymanezyk, Patrick Dickinson, Tom Duckett**
University of Lincoln
Brayford Pool, LN6 7TS
+44 (0)1522 882000
oszymanezyk@lincoln.ac.uk, pdickinson@lincoln.ac.uk, tduckett@lincoln.ac.uk

## ABSTRACT

Crowds of non-player characters improve the game-play experiences of open-world video-games. Grouping is a common phenomenon of crowds and plays an important role in crowd behaviour. Recent crowd simulation research focuses on group modelling in pedestrian crowds and game-designers have argued that the design of non-player characters should capture and exploit the relationship between characters. The concepts of social groups and inter-character relationships are not new in social psychology, and on-going work addresses the social life of emotions and its behavioural consequences on individuals and groups alike. The aim of this paper is to provide an overview of current research in social psychology, and to use the findings as a source of inspiration to design a social network of non-player characters, with application to the problem of group modelling in simulated crowds in computer games.

## Keywords

Crowd simulation, Group modeling, Character design, Social emotion, Computer games.

## INTRODUCTION

Many computer games involve the use of large open worlds with a distinct game-play focus on player exploration and discovery. Although these games are considered graphically immersive and fun to play, the population of virtual worlds by non-player characters (NPCs) has often been criticised for being mostly neglected by game designers (Szymanezyk *et al.*, 2011). Games designers have introduced virtual characters as a powerful tool way to populate these worlds to strengthen the gaming experiences (Monret 2008, Jefferies 2007). However, with the growing availability of computing resources and the increasing focus on stronger gaming experiences, video-game players can expect these worlds to be populated with crowds of NPCs. Additionally, crowds are required to perform in a believable way through emotional responses to game events or social interaction. Although there is plenty of research on virtual games character design, especially in the area of character-driven game design (Lankoski, 2010), the area of socially interacting crowds in terms of emotional behaviour has been more or less neglected in computer games research.

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**Figure 1:** Example scene from *Grand Theft Auto IV.* underlining the lack of life throughout the streets of the metropolitan city.

Crowd simulation is receiving much focus from non-computer games research areas such as artificial intelligence (SpirOps, 2011), architecture (Pelechano *at al.*, 2007), safety and security (Djordjevich *et al.*, 2008), computer graphics (Dobbyn *et al*., 2005) and sociology (Jager *et al.*, 2001). The psychological, emotional and behavioural aspects of groups in crowds have also been heavily investigated by social psychology researchers (Leach and Tiendes 2008, Parkinson *et al.* 2008).

This work analyses the current state of social behaviour between characters in computer games. It discusses the current problems in terms of sparse character population in relationship to open-world games in order to improve their believability and player game-play experiences. To achieve this, this paper argues that crowds of grouped characters should be implemented, and that a network-type data structure should be used to explore and simulate emotional behaviour when considering social groups. As such a network that captures these traits needs to be defined first, this work analyses the ongoing research in video-games character design, crowd simulation and social psychology. This paper argues that by combining these areas of research, they can be used as a source of inspiration to derive a network that captures the relationships and the resulting behaviour between characters. Using this network, game developers would be able to implement more believable characters and crowds in open-world games, thus strengthening the game-play experiences of players.

## CURRENT STATE OF CROWDS IN COMPUTER GAMES

Computer games that offer large virtual environments with open-world game-play have captivated the attention of many players. Games such as *Farcry 2* (Ubi Soft, 2008), *Crysis* (Crytek, 2007), and *Grand Theft Auto IV* (Rockstar, 2008) have often been acclaimed by game reviewers for their graphical representation, deep game-play and massive immersion. Although receiving much praise, such open-world games suffer greatly from a lack of believability in terms of their virtual populace, and only a sparse amount of NPCs are spread throughout the world. For instance, the environments of *Grand Theft Auto IV* have often been criticised for feeling lifeless and empty. When taking into consideration that the game is set in a metropolitan city, pavements and high streets should be flooded with crowds. Conversely, as shown in Figure 1, this is not the case. Furthermore, the reactions of characters in the game are argued to be limited as they

**Figure 2:** Crowd reaction examples from *Call of Duty: Modern Warfare 2*. Individuals can be seen to (a) surrender (b) help each other (c) flee in panic.

do not generate believable responses to events. Nevertheless, not every open-world game suffers from a sparse population of virtual characters. For example, the environments of the popular open-world video-game series *Assassin's Creed* (Ubi Soft, 2008), which is set in historical medieval cities, are populated by crowds composed of merchants, knights and peasants who fulfil daily routine activities. According to an interview (Raymond, 2007), the goal of the game designers was to provide a new entertainment experience based on crowd game-play, advancing new levels of interactions within a living environment. The player can interact directly with the crowd, and, as part of the game-play, they generate believable reactions. For instance, a violent open conflict causes the crowd to panic and flee, whereas a devious, sneaky assassination will go unnoticed for a while, allowing the player to blend into the perplexed and confused crowd to escape the crime scene. Another good example of the use of crowds is the first-person-shooter *Call of Duty: Modern Warfare 2* (Infinity Ward, 2009). Despite not being an open-world game, and relying heavily on scripted events, simulated crowds have been used during certain missions. For instance, in the mission named "No Russian", the player engages in a violent terrorist attack in a crowded airport. The objective is to cause as much distress and havoc as possible among travellers as part of the game-play. Upon firing the first shots, members of the crowd can be seen to surrender, to help each other, and to flee in panic (see Figure 2), simulating the reaction of crowds in such an event in a believable way. The video-game series *Assassin's Creed* and *Call of Duty: Modern Warfare 2* can be considered as good examples of the use of simulated crowds to generate more believable game-play experiences for the player.

Computer scientists and researchers have been using the recent rise of available computing resources to study and implement the complex and cultural patterns of crowds. The study of human crowd dynamics has found great interest in many research fields, such as architecture, safety and security, computer graphics, sociology and entertainment. For instance, Shao and Terzopoulos (2007) address the challenging problem of simulating the behaviour of virtual pedestrians in a simulated train station; Sung *et al.* (2004) investigate the computational scalability of crowds with increasingly complex behaviour; and Schultz and Fricke (2010) are working towards improving passenger management and movements at airports.

The use of a biologically-inspired emotion model to generate believable behaviour of characters has recently been discussed (Pelechano *et al*. 2007, Lankoski 2010, Schaap and Bidarra 2008). They argue that emotional behaviour should be embedded into characters to augment their believability. As emotions influence and dictate the way in which many decisions are taken, artificial intelligence researchers are investigating methods to implement emotional behaviour into their characters (Delgado-Mata, 2004). In our previous work (Szymanezyk *et al.*, 2010), we investigated group emotion modelling in relation to virtual crowds to simulate pedestrians in an urban context. However it was concluded that more studies into emotion modelling were required in order to improve the believability of the presented crowd simulation. Emotion modelling is also a popular topic in the field of robotics. Major advances using the Pleasure-Arousal-Dominance (PAD) demonstrate the use of emotions to augment the believability of robots (Miwa *et al*. 2001).

Grouping is a common phenomenon in pedestrian crowds, which plays an important role in the behaviour of crowds (Aveni, 1977). Nevertheless, modern crowd simulation were largely implemented without the aspect of grouping. Less weight has been put onto the modelling of social groups, group structures, and the emotional impact of such groups on the behaviour of crowds.

From a psychological point of view, research into crowd and group dynamics is not novel. Many social psychology researchers have long investigated the drive of human beings to categorise themselves into groups (Leach and Tiendes 2008, Parkinson *et al.* 2008, Fisher and Manstead 2008, Fiske *et al.* 2001, Brewer and Alexander 2005).

The social aspects of emotions are also increasingly being researched from the discovery that emotions involve socially constructed meanings which occur in a social context. For instance, Parkinson *et al*. (2005) present evidence that emotions are not only personal. Emotions can be seen as social as they help to evaluate and navigate the strengths of social relationships with in-group and out-group members.

From a games design point of view, Lankoski (2010) argues that in-game characters should express emotional responses that are believable to their context. He also argues that characters should not only be designed with a focus on themselves, but they should also be designed with the social relationships that exist between characters in mind. His argument can be extended to the problem of crowd simulation, as crowds can be seen as collections of characters. Parkinson *et al.* (2005) collected several definitions of group; a group is usually seen as an aggregation of people organised by structural factors, such as role and status, which are interrelated in a social structure.

Consequently, if we want to augment the believability of simulated crowds in computer games through the modelling of groups, character design needs to take into account the above arguments by designing individuals in crowds who respond emotionally to events and who consider their social relationships between characters as significant (Lankoski 2010). These relationships should be explored and exploited to simulate social emotions between in-group and out-group members to generate believable behaviour. This would result in stronger game-play experiences for the player. Therefore, the focus of this paper is to investigate the current status of crowd simulation research. It is our aim to extend the ongoing research with an experimental approach. We use emotion modelling, group modelling, social emotion and social cognition as a source of inspiration to develop a network that captures the relevant social and behavioural traits of pedestrian groups in order to further augment the believability of simulated crowds. It is our belief that modelling group structures and intergroup emotions will lead to more realistic crowd behaviour simulation. In return, this would improve the believability and game-play experiences emerging from virtual worlds in computer games.

## GROUPS IN SIMULATED PEDESTRIAN CROWDS

Although there is no definite upper limit to the size of a group, in this work, we define a group as small if each group member has the opportunity for immediate face-to-face interaction with all other members of the same group. The term group is used throughout this paper in its sociological sense. That is, it does not refer to several proximate pedestrians that happen to walk close to each other, but to individuals who have social ties and *intentionally* walk together, such as friends or family members.

Several methods that face the challenges of real-time crowd simulation have been proposed. Most notable are the works of Reynolds (1987), Helbing (2001), Shao and Terzopoulos (2007) and Musse and Thalmann (2007), which popularised the field of crowd simulation. However, we will not review these previous works here, as they mostly consider crowd simulation in individualistic terms and do not focus on modelling the group aspects of crowds. Instead, we focus on recent papers that explore group behaviour models in pedestrian crowds.

Qiu and Hu (2009) present a framework for modelling the structural aspects of groups in pedestrian crowds. Their framework consists of generating a pedestrian crowd which is instantiated from several predefined groups of different sizes. Individuals belong to one and only one predefined group, which is led by a group leader. Within a group, members influence and are influenced by other group members. This influence is referred to as the *intra-group* relationship. Besides member-to-member influences, groups may be influenced by each other, referred as the *inter-group* relationship. The strengths of the *inter-* and *intra-group* relationships are pre-specified by matrices. Qiu and Hu (2009) use these matrices to capture all the information needed to specify the group structure and influences. To evaluate their approach, the framework was implemented in *OpenSteer,* an open source library for constructing steering behaviours for autonomous characters in games and animation (Reynolds, 2004). They conducted different qualitative and quantitative experiments which involved modifying simulation parameters, for example constantly increasing *inter-* and *intra-group* values, while observing and evaluating the resulting crowd behaviour. The qualitative results demonstrate how the group size, *inter-* and *intra-group* structure and relationships alter the simulated crowd behaviour. Modifying the strengths of the *intra-group*s matrix allowed the simulation of different group sizes with a variety of group shapes. Altering the strengths of *inter-group* relationships demonstrated how groups are more or less likely to follow other groups. The stronger the *inter-group* relationship the more likely groups followed each other, forming larger clusters of individuals. The quantitative results involved measuring the flow of people passing through a virtual gate in a hallway scenario. The experiments showed that pedestrian flow decreases as the intra-group influence strengthens or the inter-group relationship increases. Both the pedestrian flow and the group size increases until a critical mass is reached, followed by a rapid decrease of the flow with growing group sizes. However, Qiu and Hu (2009) criticised their own work as the *inter-* and *intra-* group structures are predefined and cannot be altered during runtime, resulting in fixed sized groups. To extend their work, they propose to add a separate layer of social or psychological factors to their model to support the determination of group formation and group dynamics.

Another relevant work on pedestrian groups in crowds was conducted by Moussaïd *et al.* (2010). They also note that most studies of crowd behaviour only consider interactions in terms of individuals. As the need to study how groups organise in space and how these spatial patterns affect the crowd dynamics, they decided to analyze and evaluate the motion of pedestrian groups under natural conditions in crowded public areas. Their data shows that a large proportion of pedestrians move in groups of size two or more, mostly affected by the social environment in which the observations were made. Next, they measured the average walking speed of pedestrians, and noted that it is clearly dependent on the density level (number of persons per unit area), and that the walking speed decreases linearly with group size. They also observed a relationship between the formation of the group and the density. At low density, group members tend to walk in a horizontal formation, where each pedestrian had their partner on the sides, at an angle of +/- 90° to the walking direction. Moussaïd *et al.* (2010) demonstrated that this configuration facilitates social interactions within the groups because each member can easily communicate with their partners without turning the back to any of them. At higher density levels, group members can no longer maintain the same linear organisation without interfering with out-group pedestrians. The average distance between group members is reduced, and groups tend to form a 'V'-like formation. It is suggested that although this formation is not flexible to move against an opposite flow in pedestrian counterstreams, it is actively created and maintained in order to support and maintain social functions. To better understand the observed data, they extended the existing model of Helbing's Social Forces Model (Helbing, 2001) with a new driving force that reflects the response of pedestrian to other group members. They implemented their model in a computer simulation using an experimental approach. They demonstrated that social interaction among group members is essential to capture the dynamics of a pedestrian crowd. In their conclusion, they reported that crowd simulation should consider social interaction to fully capture the crowd dynamics and that these aspects should be taken into account in future studies and simulations of crowds.

As Moussaïd *et al.* (2010) and Qiu and Hu (2009) underline, there is a need for simulating groups in pedestrian crowds. Although their methods offer solutions to simulate groups in crowds, they conclude that there is a need to study the social interaction and social networks when considering groups in pedestrian crowds. Therefore, we suggest to investigate social groups in relationship to crowd simulation, emotion and emotion modelling, social emotion, social cognition and out-group image theory. Whereas social relationship, emotion, emotion modelling and social emotions try to capture the essence of emotions when considering their social importance, social cognition and out-group images focus on the resulting passive and active behaviour resulting from those emotions towards certain groups and individuals. It is believed that these subjects can provide suitable inspiration from which a computational model, that captures the required traits to simulate social interaction and social networks in groups of pedestrians, can be developed.

## SOCIAL NETWORKS IN RELATIONSHIP TO CROWD SIMULATION

Isbister (2006) investigates game character design from a computer games perspective. She points out that social networks are an important aspect in game character design. She suggests that game designers should not only focus on designing the characters themselves, but also on exploring and using the relationships between characters to augment their believability. This point of view is strongly supported by Lankoski (2010), who discusses how games should be designed to make social networks part of characters in order to offer new entertaining game-play experiences to players. The idea of exploring social connections between individuals can be extended to crowd simulation, especially if groups are considered. Parkinson *et al.* (2005) see groups as an aggregation of people organised by structural factors, such as role and status, which are interrelated in a social structure. However, Lankoski (2010) points out that Isbister (2006) discusses very little on how social relations can be implemented. Therefore, Lankoski (2010) proposes that to augment the believability of game characters, they should use a multitude of overlapping social networks. These social networks should be used to control the actions different characters can or must take and the consequences of such actions. They should also be used to model relationships to include relevant traits of character liaison.

In his work, Lankoski (2010) surveys Social Network Analysis (SNA) and Actor-Network Theory (ANT) as methods to model social networks. SNA is typically based upon graphical models consisting of nodes representing people and links representing various mathematical measures to identify specific social characteristics. ANT stipulates that actors in social networks should not only be humans; instead they are collections of heterogeneous entities consisting of humans, human-tool combinations and non-humans. ANT and SNA are considered as useful tools for designing and evaluating character relationships. However, it can be argued that these models do not include sufficient information to capture the traits of pedestrian crowds, such as the emotional strengths between groups, which are required when considering social groups and the resulting emotions.

Preliminary research shows that there is a wide array of available psychology literature on the social life of emotions (Tiedens and Leach, 2004), as well as on the emotions in social relations (Parkinson *et al*. 2005). Therefore, we decided to investigate the traits of group emotion in order to model groups in pedestrian crowds. It is believed that with the help of ongoing research in social emotions, the general believability of crowds in video-games can be improved.

## EMOTIONS

Although there is a general acceptance behind the term emotion in everyday use, its concept presents a particularly difficult problem from a research perspective. Although there is substantial available literature on the subject of emotions, the term has found no proper consensus on its definition. Many researchers, e.g. Scherer (2005), have tried to define what emotions are and how to evaluate them. Although the present section discusses emotions, it will not be expanded it into a systematic review of the previous work on the topic of emotions, as this would be out of the scope of this paper. Therefore, we limit ourselves to the definition of emotion as proposed by Scherer (2005), which has generally been accepted in the field of appraisal theory (Tiedens and Leach 2004, Parkinson *et al*. 2005).

Scherer (2005) defines emotions as "*an episode of interrelated, synchronised changes in the state … of the organismic subsystems in response to the evaluation of an external or internal stimulus event as relevant to major concerns of the organism*". This definition suggests that emotions are responses to either internal or external events, which have been evaluated for its significance by the system. The definition also suggests that the event is appraisal driven and its consequences must be relevant to the system - we do not generally get emotional about things or people we do not care about. As Scherer (2005) discusses, emotions also prepare for adaptive action tendencies and their motivational underpinnings; they have a strong effect on emotion-consequent behaviour, often interrupting ongoing behaviour sequences and generating new goals and plans. In addition, emotions have a strong impact on communication which may also have important consequences for social interaction.

Scherer (2005) points out that there is no single gold-standard method to measure emotions. However a range of methods have been pioneered in recent years: the discrete emotions approach, which uses natural language to describe emotions, and the dimensional approach, which uses a dimensional space that capture the locus of emotions. Both approaches have been used mostly for evaluating emotions of survey participants (Scherer, 2005). Furthermore, the dimensional approach and most noticeably the Pleasure-Arousal-Dominance (PAD) model is a prevalent tool to compute emotions in related areas such as robotics (Miwa *et al*. 2001, Qingju *et al*. 2008) and in computer vision (Cao *et al*., 2008). Characters in computer games have also been proposed by Schaap and Bidarra (2008) to use the PAD model to simulate emotions. They argue that the use of character emotion provides players with a more immersive game experience as it helps NPCs to simulate and express compelling emotional responses.

## SOCIAL EMOTION

From the perspective of social psychologists (Leach and Tiendes 2008, Parkinson *et al.* 2008) there are abundant ways in which emotions are inherently social. As defined in the previous section, emotions are typically considered as responses to relevant events, and social psychologists classify social interactions as relevant events, as they are experienced on a daily basis, generating strong emotional experiences.

As it is in the human nature to seek, explore and exploit social bonds, emotions can also be seen as social. Everyday experiences affiliate us with others as we work together with others, and seek harmony, closeness and love with others. On the other hand, we perceive those who compete or pose a threat to us as opponents that we try to avoid. From this perspective, social psychologists suggest that we cannot know anything about the strength of our social relationships without considering the emotions that emerge from them. Therefore, social psychologists defined the term "social emotion" which encompasses emotions that contribute to and evaluate social life.

Fisher and Manstead (2008) and Parkinson *et al*. (2005) have recently advanced the idea of "social emotion". They see emotions as important to social survival as the emotions that we experience and express help to form and maintain social relationships and to establish or maintain a social position relative to others. In discussing their argument, they categorise the social function of emotion into two separate levels; *interpersonal emotion* and *intergroup emotion*. These two levels try to capture the experience of emotions when considering their social function and are used to describe the different levels of emotions emerging from social interaction between individuals within a group and between groups.

### Interpersonal emotion

Parkinson *et al.* (2005) discuss how the interpersonal level focuses on the direct relation and the interaction with other people, and on how the behaviour of others influences and is influenced by our own behaviour. They argue that these interactions and the relations that grow at the interpersonal level can become the most memorable and meaningful aspect of our social life. Parkinson *et al.* (2005) are working towards understanding how interpersonal emotions capture interpersonal dynamics and how they constitute and evaluate relationships during the unfolding social life between people over time.

### Intergroup emotion

As according to Parkinson *et al.* (2005) the second level permits us to consider how individuals' conduct is shaped and being shaped by the fact that they categorise themselves and others into social groups. Supported by previous research done on the subject, Parkinson *et al.* (2005) argue that it is in the human nature to think about the world in terms that emphasises the segmentation between us and others. There is a large variety of definitions that describe the homogeneity of people in social groups, and contemporary news tends to reinforce these views as it often report how various groups are competing against each other. Working at the *intra-group emotion* level, Parkinson *et al.* (2005) suggest that we can start to understand social emotions when individuals classify themselves and others as part of one group and how groups interact with each other. *Intergroup emotions* focus on the groups' standing relative to each other and the emotions that are involved in typical intergroup relationships such as conflict, competition, prejudice and political manoeuvring. Table 1 helps to distinguish the different levels on which social emotions operate, as discussed by Parkinson *et al.* (2005).

## SOCIAL COGNITION

Recent research in social cognition has established warmth and competence as universal dimensions of social judgement. When encountering others, people determine, almost immediately, the intentions of the other person or group, then, whether the other person or group have the abilities to act upon those intentions. Ongoing research supported by Fiske *et al.* (2001) shows that there are two universal dimensions of social cognition: warmth and competence. The warmth dimension captures traits that are related to perceived intent, including friendliness, helpfulness, sincerity, trustworthiness and morality, whereas the competence dimension reflects traits that are related to perceived ability, including intelligence, skill, creativity and efficacy. Using these two traits, Fiske *et al.* (2001) say that people can judge and evaluate other individuals and groups, and decide which behaviour to adopt during interaction.

| **Subject** | **Individual** | **Group** |
|---|---|---|
| **Individual** | Interpersonal emotions | Individual emotions directed toward a group |
| **Group** | Group emotions directed toward an individual | Intergroup Emotions |

**Table 1:** Interpersonal, Group, and Intergroup emotions.

In addition, Fiske *et al.* (2001) propose that certain combinations of competence-warmth appraisals result in the perception of different groups of stereotypes. When people are asked to judge individuals, the two dimensions often correlate positively, however when people are asked to judge social groups, warmth and competence often correlate negatively. Many groups are judged as high on one dimension and low on the other, which has, according to Fiske *et al.* (2001), important implications for predicting affective and behavioural reactions.

Distinct types of intergroup affect result from each warmth-competence relationship. As a consequence, this elicits diverse intergroup emotions such as contempt, pity, envy or pride, and different predicted behaviour of harm or facilitation. This is captured by the behaviours from so-called intergroup affect and stereotypes (BIAS) map shown in Figure 3. Emotions are represented by grey arrows on the diagonal axes, whereas behavioural tendencies are represented by black arrows on the horizontal and vertical axes. Therefore, groups and people in different quadrants are seen as receiving one predicted emotional prejudice and two predicted behaviours. The warmth dimension predicts active behaviours such as active facilitation (helping) or active harming (attacking). The competence dimension predicts passive behaviour such as passive facility (association) and passive harm (neglect). For instance, groups or individuals rated as high in competence and low in warmth elicit envy and results in active harm and passive facilitation towards this person or group.

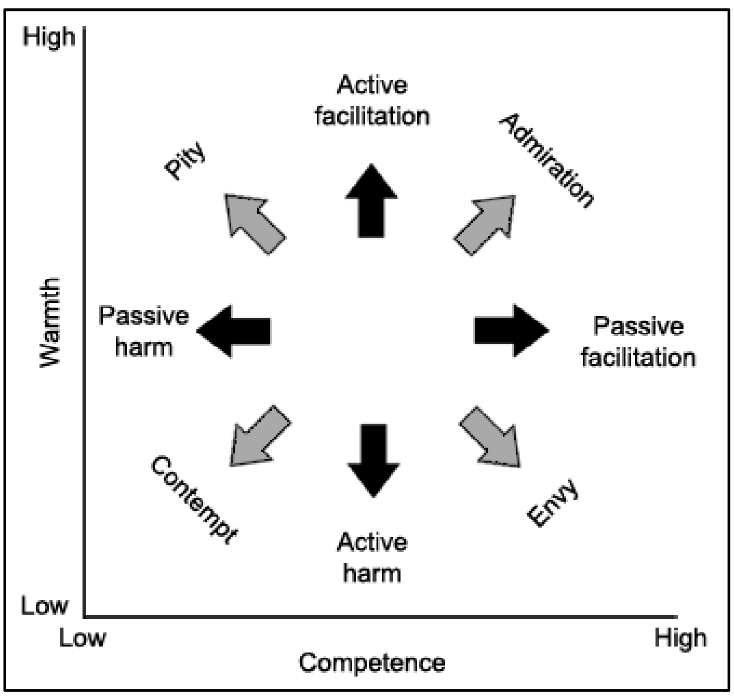


**Figure 3:** Distinct types of behaviour and emotion result in the warmth by competence space. (According to Fiske *et al.*, 2001).

## OUT-GROUP IMAGES AND INTERGROUP EMOTIONS

Another approach to the issue of out-group directed emotions and related predicted behaviour has been offered by Brewer and Alexander (2005). They examine the implications of having a certain image of a specific out-group. An image, in the context of their research, is seen as a cognitive, affective and evaluative structure to help to understand and shape the perception of relationships that an in-group forms with out-groups. Therefore, images give useful pointers regarding the types of appraisals that are relevant to the formation of out-group images, and the emotions that correspond to these appraisals. The images and their related out-group emotions are listed in Table 2. Brewer and Alexander (2005) identify five images arising from different forms of in-group-out-group relationship. The key idea underlying their application of image theory to intergroup emotion is that it is the character of the relationship between in-group and out-group that determines how members of the in-group want to act toward the out-group, what image they have of the out-group, and what emotions they feel towards out group members.

| **Out-group image** | **Appraisal pattern** | **Action tendencies** | **Out-Group Emotions** |
|---|---|---|---|
| Ally | Goal compatibility<br>Status equality<br>Power equality | Cooperation | Trust, Admiration |
| Enemy | Goal incompatibility<br>Status equality<br>Power equality | Containment<br>Attack | Anger |
| Dependent | Goal independent<br>Status inferiority<br>Power equality | Exploitation<br>Paternalism | Disgust<br>Contempt |
| Barbarian | Goal incompatibility<br>Status inferiority<br>Power superiority | Defensive protection | Fear<br>Intimidation |
| Imperialist | Goal independent<br>Status superiority<br>Power superiority | Resistance<br>Rebellion | Jealousy<br>Resentment |

**Table 2:** Images related to appraisals, action tendencies and out-group emotions (As discussed by Brewer and Alexander, 2005)

## DISCUSSION

In this paper, we have described the current status of the behaviour of pedestrian crowds in open-world computer games. It was shown that the use of crowds involving a large number of NPCs is a popular design choice by game designers to augment the believability of open-world games. Nevertheless, virtual humans composing a crowd have often been modelled only in terms of individuals. Research in crowd behaviour identifies that a large majority of persons in real crowds do not act in individualistic terms, but engage in small social groups. Individuals influence and are influenced by other group members and groups, resulting in distinct behavioural patterns. Although emotional behaviour has been proposed to augment the believability of NPCs, ongoing research in crowd simulation has not yet captured the essential qualities of the social aspects of emotions, especially when considering group interaction in crowds. We have also discussed the need for exploring and exploiting the social links between characters to augment their believability as an ongoing area of research in game design. Key models from social psychology research were explored and they were related to video-game character design. In order to move towards improving player experiences in open-world games using crowd simulation, we propose to use the presented sociology work as a source of inspiration for improving character behaviour in situations in which simulated crowds are required.

Earlier in this work, we discussed the use of the Pleasure-Arousal-Dominance (PAD) model. It is currently used to simulate emotions for many different types of computer controlled characters (Miwa *et al.* 2001, Qingju *et al.* 2008, Cao *et al.* 2008, Schaap and Bidarra, 2008). However, it can be argued that the PAD model does not capture the social aspect of emotions (Leach and Tiendes 2008, Parkinson *et al.* 2005). As characters need to explore a social network in order to augment their believability (Lankoski 2010, Isbister 2006), and as simulated crowds need to consider group aspects (Moussaïd *et al.* 2010, Qiu and Hu 2009), we propose to create a network-type data structure with the help of on-going sociology work. The aim of this data structure is to capture the required traits in order to simulate the social aspects of emotions and the resulting behaviour of virtual characters in crowd situations.

Throughout the previous sections, the relevance of emotions towards social interaction and their resulting behaviour when considering groups of people were discussed. We have explored the research of Parkinson *et al.* (2005) on social emotions. Their work considers the social life of emotions on two separate levels, the *interpersonal* level, which focuses on the direct relation and interaction with other people, and the *intergroup* level, which captures the groups' standing relative to each other and the emotions that are involved in group conflict, competition, prejudice and political manoeuvring. Fiske *et al.* (2001) discuss social cognition. Their work establishes warmth and competence as universal dimensions of social judgement, as a method to capture and evaluate diverse intergroup emotions such as contempt, pity, envy or pride, and different behavioural approaches such as harm or facilitation. Brewer and Alexander (2005) identified five images that arise from different types of in-group-out-group relationship. These images represents the character of the relationship between in-group and out-group, which determines how members of the in-group want to act toward the out-group, what image they have of the out-group, and what emotions they feel towards out group members.

Although we have only explored the surface of a handful of these subjects, given their complexity, we propose to use them a source of inspiration to implement a computational model for use in video-games that captures the sociological influences of pedestrian characters in crowds.

Consider, for instance, the scenario presented in Figure 4, which shows ten NPCs split up into social groups A, B and C. NPC3 is a member of both group A and group C. The figure shows the intergroup and interpersonal emotional relationships discussed by Parkinson *et al.*(2005). Although the figure does not capture any interesting scenarios, if we theoretically apply the social cognition theory of Fiske *et al.* (2001) and the out-group images theory of Brewer and Alexander (2005), a range of scenarios can be generated. For instance, it would be possible to predict the behavioural reactions between groups; e.g. group A considers group C as highly warm and highly competent. According to social cognition theory (Fiske *et al.* 2001), the elicited out-group emotion is admiration. Admiration is considered as the 'Ally' out-group image by Brewer and Alexander (2005), resulting in the action tendency of cooperation. In another example scenario, groups A and C portray group B as being low in warmth and average in competence, the resulting intergroup emotion would be active harm, and the resulting behavioural tendency containment and attack. A third scenario would be to consider groups A and C as being hostile towards each other; NPC3, who is part of both groups would in return have mixed interpersonal emotions towards his group members.

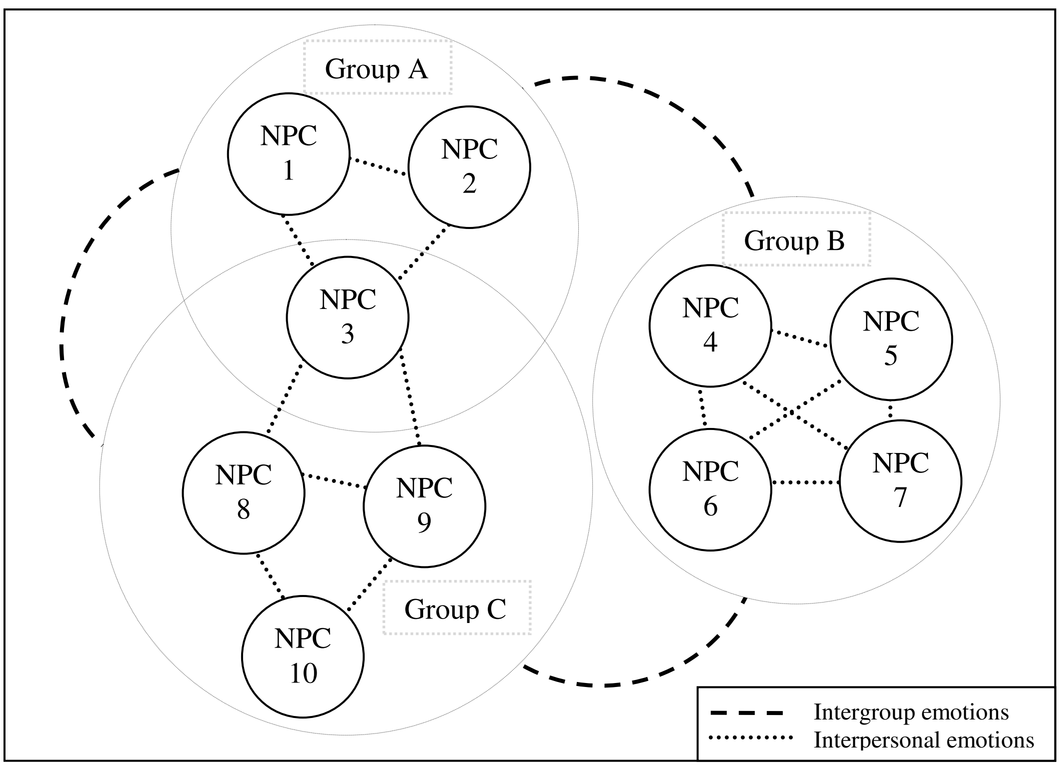


**Figure 4:** Example of ten non-player characters categorized according to three social groups and their relationships towards each other.

Figure 4 could be considered as only showing a subset of a crowd, and the example could be further elaborated to capture the socio-psychological aspects of pedestrian groups. For instance, Qui and Hui (2009) propose to extend their work on pedestrian groups with a separate layer of social or psychological factors added on top of their model to support the decision of group formation and group dynamics. Using a network that is inspired by our work, such an extension could be designed.

To extend this work, we propose to support the findings of group emotion and group behaviour with further research about crowd dynamics and use the findings as a source of inspiration to develop a network, model or layer that captures the traits of social emotion for application in computer games. The findings should in return be able to capture the relationships between characters and the resulting behavioural actions. They would be used to simulate believable behaviour between characters. The work would then be extended from individual characters to large crowds, thus offering a suitable social network in order to augment the believability of open-world video-games through exploring social emotion in pedestrian groups.

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