Emotion, Personality and Cultural Aspects in Crowds: towards a Geometrical Mind

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***Abstract*—In this work we proposed a computational model to extract pedestrian characteristics from video sequences. The proposed model considers a series of characteristics of the pedestrians and the crowd, such as number and size of groups, distances, speeds, among others, and performs the mapping of these characteristics in personalities, emotions and cultural aspects, considering the Cultural Dimensions of Hofstede (HCD), the Big-Five Personality Model (OCEAN) and the OCC Emotional Model. The main hypothesis is that there is a relationship between so-called intrinsic human variables (such as emotion) and the way people behave in space and time. As one of the main contributions, four large dimensions of geometric characteristics (Big4GD) were proposed: *I - Physical*, *II - Personal and Emotional*, *III - Social* and *IV - Cultural*, which seek to describe the behavior of pedestrians and groups in the crowd. The *GeoMind* tool was developed for the purpose of detecting the four geometric dimensions from video sequences. In addition, several analyzes were carried out with the purpose of validating the proposed model, from comparing results with the literature, including the comparison of spontaneous multitudes from several countries and controlled experiments involving Fundamental Diagrams.**

***Index Terms*—Crowds, Cultural Aspects, Personality, Emotion**

I. Introduction

The study of human behavior is a subject of great scientific interest and probably an inexhaustible source of research [1]. There are many applications such as entertainment (games and movies), understanding of human behavior, security and surveillance, urban planning and activity recognition [2], [3]. When a group of individuals shares the same physical space and has a common goal, they have the characterization of a collective and highly dynamic or, more broadly, a crowd [4].

Chattaraj et al. [5] suggest that cultural and population differences can produce changes in the speed, density, and flow of the crowd. Interested in these aspects, Geert Hofstede created a model of culturality, which became known as the Cultural Dimensions of Hofstede (HCD) [6]. Another factor that can interfere in the cultural aspects of a group of individuals are the personality and emotion of each one. Regarding personality, we adopted the personality model *Big-Five* [7], [8]. It is a descriptive (taxonomic) psychological model of five factors of personality traits. Related to emotions, Ortony, Clore and Collins's [9] proposed an emotion model called OCC.

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Following this line of research, this work seeks to explore the cultural factors of multi-country crowds from video sequences. The main goal is to **develop a computational model for detection and analysis of pedestrian and group features in crowds from video sequences**. The idea is to use characteristics of the crowd and their individuals, such as: average distance between people, number and size of groups, speed, density, directions, among other factors that may vary according to the type and nationality of the population to detect and characterize personal, social, emotional and cultural aspects. In particular, we want to propose new factors/dimensions that can be used to characterize crowds, groups and their individuals relating intrinsic features as cultural aspects, personalities and emotions to physical and geometrical manifestations (distances, speeds and so on).

A. Motivation and Contributions

In the literature, some work seek to simulate different types of crowds, e.g. addressing aspects of gender and age [10], [11]. Computational simulation models that consider, in addition to these factors, data such as culture and habits are still rare [12] and require a thorough state-of-art study of other areas of knowledge, such as psychology and anthropology. Reproducing the real characteristics of a crowd in simulation is a challenging task [13] and methods that explore cultural aspects in simulated and real crowds are still uncommon.

The motivation for the research in this area starts from the need to have computational tools and models that are capable of extracting characteristics from real pedestrians and crowds, benefiting several other areas of knowledge, e.g. the computational simulation. The relevance of this research is justified due its diverse applications, such as physical space planning, entertainment and security management, among others. These areas seek to consider regional and cultural aspects, but usually this is done with empirical knowledge, there is no computational method or model to help in this task. In the area of physical space management and planning of environments, regional and cultural behaviors and habits should be considered [14], [15]. For example, in Arabian

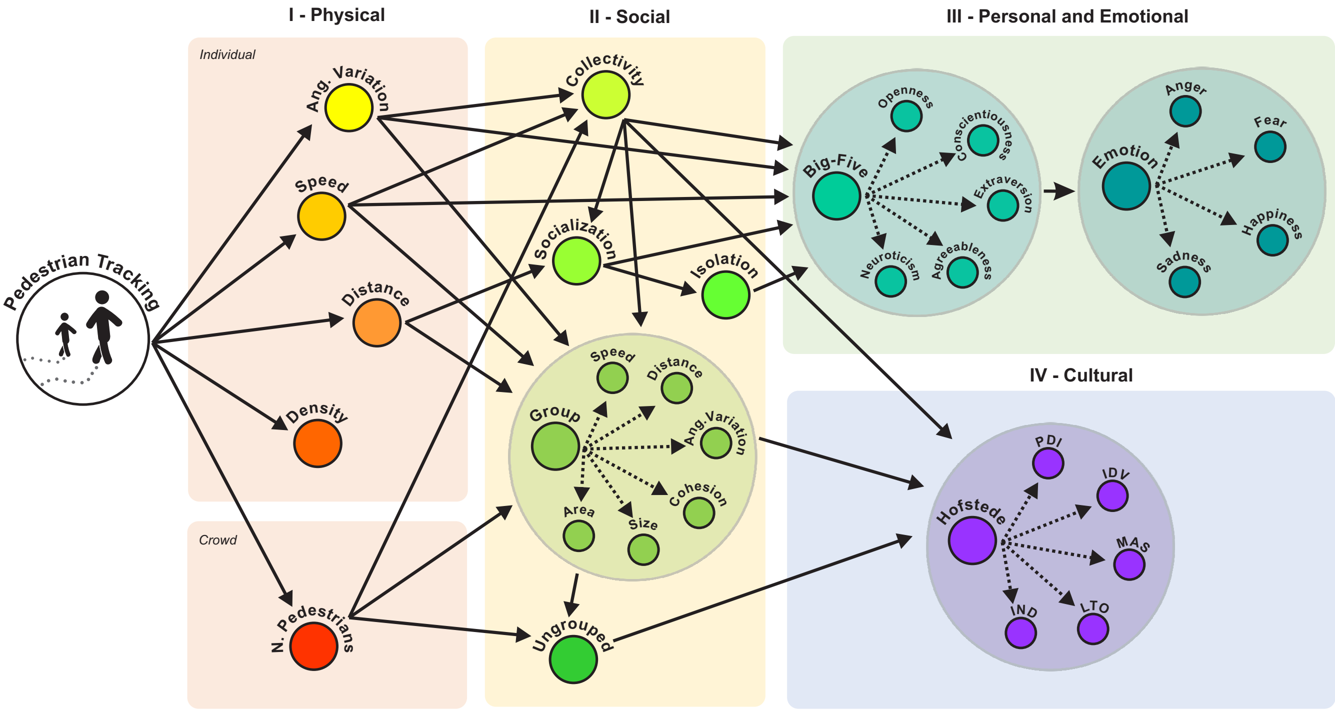

Fig. 1. **Our Big-Four Geometrical Dimensions**: features mapping from the proposed approach divided into four dimensions: *I–Physical*, *II–Social*, *III–Personal and Emotional* and finally, *IV–Cultural*.

cities, the provision of public and private spaces is, for the most part, very different from the European cities, according to an study performed by [14].

When it comes to entertainment field, the production of movies and computer games can benefit from the study of cultural aspects. The crowds in the games could be more realistic and include cultural characteristics, typical of each region or country. A crowd of people in a game in Florence in Italy could behave differently from a crowd in a game that takes place in Rio de Janeiro in Brazil, for example. The same goes for the film industry, where pedestrians from simulated crowds could have characteristics and behaviors which are typical of the location of the film's narrative. With respect to the security area, detection of abnormal events could consider cultural aspects, so a strange behavior performed by a pedestrian or a group of pedestrians in France may be different from a strange behavior performed by a pedestrian from Germany.

In order to address this problem, we proposed the development of a computational model that allows the extraction of pedestrian and crowd characteristics based on their behaviours manifestation in space/time, being able to identify cultural, personality and emotional aspects and behaviors that differ from one country to another. Fig. 1 shows an overview of the features mapping from the proposed approach. Directional arrows indicate which features are used as inputs to calculate other, for example, *distance* is used as input to calculate *socialization* and to detect *groups*.

As one of the main contributions of this thesis, we proposed four different dimensions of features to characterize pedestrians organized in groups/crowds in video sequences. These dimensions, named as **Big-Four Geometrical Dimensions** or just **Big4GD** model, illustrated in Fig. 1, are:

- *I – Physical*, which keeps the physical features of pedestrians obtained directly from the tracking, such as speeds, distances from a pedestrian from others, angular variations, among others;
- *II – Social*, which derives from the Physical dimension and deals with social interaction, characterizing groups of pedestrians and social features, as collectivity, isolation and socialization levels of individuals;
- *III – Personal and Emotional*, which maintains the features related to personality (Big-Five) and emotion (OCC) traits;
- *IV – Cultural*, which deals with features regarding cultural aspects, according to Hofstede (HCD).

Naturally, we make no claims regarding the validity of this approach as a scientific tool for assessing cultural, personality or emotional profiles of real people because it is hard to know the intrinsic variables of human beings (personalities/emotions/culture) and to relate that with humans physical/geometrical manifestation. This approach is a hypothetical model (tested in same examples) to detect our proposed dimensions and its validity in a set of videos as well as some specific literature. Our main hypothesis is that it is plausible to propose a computational model that based on pure geometrical input information can be used to find out some intrinsic information, i.e. correlate geometric manifestations with emotion/personality/cultural aspects. All proposed dimensions and other analysis and experiments, together with the background and related work, are described in details in the thesis manuscript attached to this submission.

A final comment about the contribution of this thesis: we did not find any model in literature that focus on find out and characterizing emotion, personalities and cultural aspects of people in pedestrians from video sequences related to their spacial/time behaviours. In the next section we describe the main byproducts of the thesis, including papers, a book published by Springer Nature, a software and a public dataset.

II. Publications and Distinctions

In addition to the geometric dimensions model proposed in this thesis, our research generated other important contributions. We have built a dataset of videos with crowds from different countries. We also developed a software for the detection and analysis of geometric dimensions in videos, along with a visualizer of features. The *Cultural Crowds* dataset and the *GeoMind* software are summarized next.

Cultural Crowds[1] is a public dataset of videos with crowds from different countries, which consists of 88 video clips with different conFig.tions. The videos were cataloged in several classification criteria, such as: crowd density, camera angle, environment, nationality and type of scene. Together these videos are files with tracking, pedestrian and crowd features and geometric dimensions information.

The software, called *GeoMind*[2] (abbreviated form of Geometrical Mind), was developed using Matlab App Desinger to the detection and analysis of geometric dimensions **Big4GD** in video sequences. It was design to be simple and easy to use, allowing users, with a few steps, to obtain a series of pedestrian features from video sequences, based on tracking. Fig. 2 shows the main interface of the software. It is possible to see the setup panel on the left side and a video summary results in the right side of the Fig. 2.

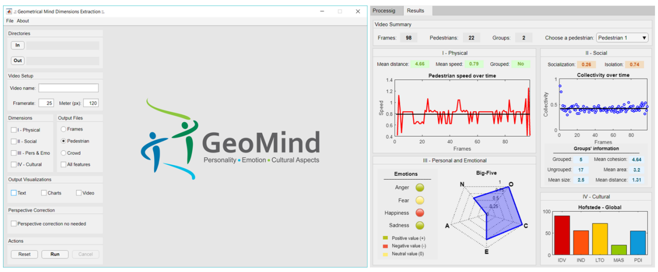

Fig. 2. **Geomind main interface**: setup panel containing the input and output configurations of the video processing (**left**) and video summary after the software processing showing the results analysis (**right**).

In terms of publications, the results obtained during the research developed in this thesis were published as several papers and a book, as described below:

[1]*Cultural Crowds* dataset is available at https://www.rmfavaretto.pro.br/vhlab/datasets.php.

[2]Download and more information about how to use *GeoMind* can be found at http://rmfavaretto.pro.br/geomind.

(*i*) R. M. Favaretto, S. R. Musse and A. B. Costa. **Emotion, Personality and Cultural Aspects in Crowds: Towards a Geometrical Mind**. Springer Nature. 2019. Available at https://www.springer.com/gp/book/9783030220778. **BOOK** [16].

(*ii*) R. M. Favaretto, R. R. dos Santos, S. R. Musse, F. Vilanova and A. B. **Investigating cultural aspects in the fundamental diagram using convolutional neural networks and virtual agent simulation**. Comput Anim Virtual Worlds. 2019. **Journal paper** [17].

(*iii*) M. S. H. Silva, P. B. S Pinto Neto, R. M. Favaretto and S. R. Musse. **Detecting Events in Crowds Through Changes in Geometrical Dimensions of Pedestrians**. SBGames. RJ, 2019. **Conference paper** [18].

(*iv*) R. M. Favaretto and S. R. Musse. **Emotion, Personality and Cultural Aspects in Crowds: Towards a Geometrical Mind**. SIBGRAPI. Rio de Janeiro, RJ, 2016. **Conference paper** [19].

(*v*) R. M. Favaretto, P. Knob, S. R. Musse, F. Vilanova, and A. B. Costa. **Detecting personality and emotion traits in crowds from video sequences**. Machine Vision and Applications, 5:999–1012, 2018. **Journal paper** [20].

(*vi*) R. M. Favaretto, L. Dihl, R. Barreto and S. R. Musse. **Using group behaviors to detect hofstede cultural dimensions**. In Int. Conf. on Image Processing (ICIP). Phoenix, AZ, 2016. **Conference paper** [21].

(*vii*) R. M. Favaretto, L. Dihl, and S. R. Musse. **Detecting crowd features in video sequences**. SIBGRAPI. São José dos Campos, SP, 2016. **Conference paper** [22].

(*viii*) R. M. Favaretto, L. Dihl, S. R. Musse, F. Vilanova, and A. B. Costa. **Using big-five personality model to detect cultural aspects in crowds**. SIBGRAPI. Niteroi, RJ, 2017. **Conference paper** [23].

(*ix*) P. Knob, M. A., E. T., R. Favaretto, G. Lima, L. Dihl, and S. R. Musse. **Generating background NPCs motion and grouping behavior based on real video sequences**. Entertainment Computing, 2018. **Journal paper** [24].

(*x*) V. Araujo, R. M. Favaretto, P. Knob, S. R. Musse, F. Vilanova, and A. B. Costa. **How Much Do You Perceive This?: An Analysis on Perceptions of Geometric Features, Personalities and Emotions in Virtual Humans**. ACM International Conference on Intelligent Virtual Agents. Paris, FR, 2019. **Conference paper** [25].

(*xi*) M. Alcantara, E. Testa, G. L. da Silva, R. Favaretto, L. Dihl, and S. Musse. **Generating background population for games based on real video sequences**. SBGames. São Paulo, SP, 2016. SBGames. **Conference paper** [26].

(*xii*) L. Dihl, E. Testa, P. Knob, G. Lima, R. M. Favaretto, M. Alcantara, and S. R. Musse. **Generating cultural characters based on hofstede dimensions**. In Virtual Humans and Crowds for Immersive Environments (VHCIE). Los Angeles, CA, 2017. **Conference paper** [27].

(*xiii*) P. Knob, V. F. de A. Araujo, R. M. Favaretto, and S. R. Musse. **Visualization of interactions in crowd simulation and video sequences**. SBGames. Foz do Iguacu, PR, 2018. **Conference paper** [28].

III. Final remarks

We proposed the **Big-Four Geometrical Dimensions**, a model containing a set of pedestrian and crowd features grouped into four dimensions. This four dimensions enclose characteristics in different levels, as pedestrian, group and crowd. Based on geometric characteristics derived from pedestrian trajectories, we propose a way of characterizing pedestrians and groups of individuals in crowds, allowing the comparison of each other to find differences between one crowd and another. Based on a series of experiments, we were able to validate our model and verify that our approach succeeds in extracting the information from the crowds and their individuals.

A big challenge in the subject of research of this thesis is the comparison with real life data. In this way, regarding personality and cultural aspects, we successfully compared our results with Psychology literature, where several studies aimed to analysis human behavior. It is important to notice that, even if the literature measured these dimensions by considering a different type of information (subjective responses of individuals collected through questionnaires), the results obtained from our approach using geometrical information indicate that our model generates coherent information when compared to data provided in available literature, as shown in various analysis along the thesis manuscript.

In addition, as one particular aspect to be considered in behavior analysis is the context and environment in which individuals behave, we performed an experiment (Fundamental Diagram, detailed in Chapter 7 of the thesis manuscript) excluding such variations by fixing tasks that the tested populations were required to execute. In this controlled experiment, we have found strong evidence of the fact that the cultural behaviours of individuals can be observed at low and medium densities, i.e., in high densities individuals exhibit mass behaviours instead of behaving individually according to their cultural background or personalities. This serves as interesting and concrete proof of several theories on mass behaviour as discussed by [29] and [30].

References

[1] J. Jacques Junior, S. R. Musse, and C. Jung, "Crowd analysis using computer vision techniques," *IEEE Signal Processing Magazine*, vol. 27, pp. 66–77, 2010.

[2] Z. Shahhoseini and M. Sarvi, "Pedestrian crowd flows in shared spaces: investigating the impact of geometry based on micro and macro scale measures," *TR Part B: Methodological*, vol. 112, pp. 57–87, 2019.

[3] W. Zhao, Z. Zhang, and K. Huang, "Gestalt laws based tracklets analysis for human crowd understanding," *P. Rec.*, vol. 75, pp. 112–127, 2018.

[4] W. Li, Z. Di, and J. M. Allbeck, "Crowd distribution and location preference," *CAVW*, vol. 23, pp. 343–351, 2012.

[5] U. Chattaraj, A. Seyfried, and P. Chakroborty, "Comparison of pedestrian fundamental diagram across cultures," *ACS*, vol. 12, pp. 393–405, 2009.

[6] G. Hofstede, *Culture's consequences: comparing values, behaviors, institutions, and organizations across nations*. Thousand Oaks, CA: Sage Publications, 2001.

[7] P. Costa and R. McCrae, *Revised NEO Personality Inventory (NEO PI-R) and NEO Five-Factor Inventory (NEO-FFI)*. New York, NY: Psychological Assessment Resources, 1992.

[8] R. R. McCrae and P. L. Costa, *Toward a new generation of personality theories: Theoretical contexts for the five-factor model*. New York, NY: Guilford Press, 1996, ch. 3, pp. 51–87.

[9] A. Ortony, G. L. Clore, and A. Collins, *The cognitive structure of emotions*. New York, NY: Cambridge university press, 1990.

[10] M. Kapadia, A. Shoulson, F. Durupinar, and N. I. Badler, *Authoring Multi-actor Behaviors in Crowds with Diverse Personalities*. New York, NY: Springer, 2013, ch. 8, pp. 147–180.

[11] N. Pelechano, J. M. Allbeck, M. Kapadia, and N. I. Badler, *Simulating heterogeneous crowds with interactive behaviors*. Natick, MA: A. K. Peters, Ltd., 2016.

[12] S. C. Moore, M. Flajšlik, P. L. Rosin, and D. Marshall, "A particle model of crowd behavior: Exploring the relationship between alcohol, crowd dynamics and violence," *AV Behavior*, vol. 13, pp. 413–422, 2008.

[13] P. Allain, N. Courty, and T. Corpetti, "Optimal crowd editing," *Graphical Models*, vol. 76, pp. 1–16, 2014.

[14] B. Hillier, "A theory of the city as object: or, how spatial laws mediate the social construction of urban space," *Urban design international*, vol. 7, pp. 153–179, 2002.

[15] P. J. M. Nas, *Cities full of symbols: A theory of urban space and culture*. Amsterdam, NL: Amsterdam University Press, 2011.

[16] S. R. M. Rodolfo M. Favaretto and A. B. Costa, *Emotion, Personality and Cultural Aspects in Crowds: Towards a Geometrical Mind*. London, UK: Springer Nature, 2019.

[17] R. Migon Favaretto, R. Rosa dos Santos, S. Raupp Musse, F. Vilanova, and A. Brandelli Costa, "Investigating cultural aspects in the fundamental diagram using convolutional neural networks and virtual agent simulation," *Computer Animation and Virtual Worlds*, vol. 30, no. 3-4, p. e1899, 2019, e1899 cav.1899.

[18] M. S. H. Silva, P. B. S. P. Neto, R. M. Favaretto, and S. R. Musse, "Detecting events in crowds through changes in geometrical dimensions of pedestrians," in *XVIII SBGames*. Rio de Janeiro, RJ: SBGames, 2019, pp. 1421–1424.

[19] R. M. Favaretto and S. R. Musse, "Emotion, personality and cultural aspects in crowds: Towards a geometrical mind," in *Conference on Graphics, Patterns and Images (SIBGRAPI)*. Rio de Janeiro, RJ: IEEE, 2019, pp. 1–7.

[20] R. M. Favaretto, P. Knob, S. R. Musse, F. Vilanova, and A. B. Costa, "Detecting personality and emotion traits in crowds from video sequences," *Machine Vision and Applications*, vol. 30, no. 5, pp. 999–1012, Jul 2019.

[21] R. M. Favaretto, L. Dihl, R. Barreto, and S. R. Musse, "Using group behaviors to detect hofstede cultural dimensions," in *International Conference on Image Processing (ICIP)*. Phoenix, AZ: IEEE, 2016, pp. 2936–2940.

[22] R. M. Favaretto, L. Dihl, and S. R. Musse, "Detecting crowd features in video sequences," in *Proceedings of Conference on Graphics, Patterns and Images (SIBGRAPI)*. São José dos Campos, SP: IEEE Computer Society, 2016, pp. 201–208.

[23] R. M. Favaretto, L. Dihl, S. R. Musse, F. Vilanova, and A. B. Costa, "Using big-five personality model to detect cultural aspects in crowds," in *Conference on Graphics, Patterns and Images (SIBGRAPI)*. Niteroi, RJ: IEEE, 2017, pp. 223–229.

[24] P. Knob, M. Alcântara, E. Testa, R. Favaretto, G. Lima, L. Dihl, and S. R. Musse, "Generating background npcs motion and grouping behavior based on real video sequences," *Entertainment Computing*, vol. 27, pp. 179–187, 2018.

[25] V. Araujo, R. Migon Favaretto, P. Knob, S. Raupp Musse, F. Vilanova, and A. Brandelli Costa, "How much do you perceive this?: An analysis on perceptions of geometric features, personalities and emotions in virtual humans," in *IVA*. ACM, 2019, pp. 179–181.

[26] M. Alcantara, E. Testa, G. L. da Silva, R. Favaretto, L. Dihl, and S. Musse, "Generating background population for games based on real video sequences," in *SBGames*. São Paulo, SP: SBGames, 2016, pp. 66–72.

[27] L. Dihl, E. Testa, P. Knob, G. Lima, R. M. Favaretto, M. Alcantara, and S. R. Musse, "Generating cultural characters based on hofstede dimensions," in *Virtual Humans and Crowds for Immersive Environments (VHCIE)*. Los Angeles, CA: IEEE, 2017, pp. 1–6.

[28] P. Knob, V. F. de A. Araujo, R. M. Favaretto, and S. R. Musse, "Visualization of interactions in crowd simulation and video sequences," in *XVII SBGames*. Foz do Iguaçu, PR: SBGames, 2018, pp. 601–610.

[29] G. L. Bon, *The Crowd: A Study of the Popular Mind*. Mineola, NY: Courier Corporation, 2012.

[30] F. Vilanova, F. M. Beria., A. B. Costa, and S. H. Koller, "Deindividuation: From le bon to the social identity model of deindividuation effects," *Cogent Psychology*, vol. 4, pp. 1–21, 2017.