A Case Study of Navigation System Assistance with Safety Purposes in the Context of Covid-19 Pandemic

Stefano Galantucci, Paolo Giglio, Vincenzo Dentamaro, Giuseppe Pirlo

A case study of navigation system assistance with safety purposes in the context of Covid-19 pandemic

Stefano Galantucci[1] [0000-0002-3955-0478], Paolo Giglio[1] [0000-0002-0426-7349], Vincenzo Dentamaro[1] [0000-0003-1148-332X], Giuseppe Pirlo[1 2] [0000-0002-7305-2210]

[1] Department of Computer Science – University of Bari
[2] Digital Innovation S.R.L., via Orabona 4 70126 Bari, Italy
Stefano.galantucci@uniba.it

Abstract. The standards defined by the human-computer interaction discipline highlight the need for renewed interpretation of services for the customer. Indeed the increasing number of original applications based on the progression of technology and the spread of sensors in almost every space (private and public) is the ground of potential benefits for the end users. Nevertheless every new advance in this scenario should take into account how technology is able to connect and be interfaced with the user natural language. In this regard, the following work proposes an analysis of the feasibility of a smart city public safety application in the context of Covid 19 exposure prevention. Particularly it will be observed how even a necessary service could be enhanced on its effectiveness if designed according to the human-computer-interaction standards.

Keywords: Human-Computer Interaction, Signal Processing ,Smart Cities Urban Safety .

1 Proposal

As the IoT technology is spreading in almost every aspect of users' life [1][2], it becomes a priority to analyze how it is changing the way it interfaces with users [3]. Indeed several critical aspects arise from this, such as the safety of end users [4] and the optimization of the interaction between users and technological devices when a service is supplied [5]. One field of paramount importance in this regard is the connection of the urban environment with the end user who is interacting with it [6][7], concerning the complexity of all services and dynamics related to it [8]. Indeed aspects of paramount importance are those of safety with regard to user interaction with surrounding entities and systems (public transportation systems, points of interests) and the ability to provide all the necessary information in order to help to satisfy its needs. This conjugation of the research field is even more demanding if the recent Covid-19 pandemic is considered: the overall urban environment presents itself as profoundly transformed, not from a structural point of view, rather by a risk-factor aspect, especially regarding its inhabitants' conduct. From this perspective, the city could progressively become a smart system that recognizes its inhabitants and "behaves" in a cooperative way with

them. The way this relation is developing is a central subject of what is generally referred as human-computer-interaction.

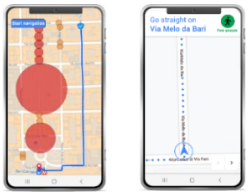

Fig. 1. An example of the front end design of the application: the red areas are indicative of the presence of crowded roads. The navigation systems determines an alternative route to reach the destination based on the objective of minimizing the potential exposure to crowded places.

This study aims to provide an ensemble of services that collectively contribute to create an enhanced user experience when using an application for safety assistance, specifically in the context of Covid 19 avoidance of crowded areas: in order to provide such a service it is developed a system of cluster recognition of humans in public spaces: the goal is to provide prompt advice to the user (which could be obliged to go to its workplace or to go food shopping) in order to avoid the most crowded places. For this purpose, an effective system should analyze the pattern of spatial distribution of people in a crowded environment. This application comes from the need to assess the covid related risk for those places that are naturally interested by a huge traffic of subjects (such as supermarkets or public transportation vehicles). A cautious user (who may also possess a delicate health condition) would be assisted in the decision of selecting the right places to fulfill its personal needs. This service has been implemented in a user-friendly app that allows the user to select a desired destination in order to receive the best route to reach the location with full safety. The overall work can be split into two main phases: a preliminary phase concerning the study of feasibility of the project along with its technical development and a secondary phase of refinement and design of the overall final technological product. As stated before, the core of this work concerns the recognition of dangerous clusters of people in public spaces and it is part of a broader technology aimed to refine the synergic interaction between the user and the public environment. In order to obtain a prompt response to the dynamical condition of the city, the method adopted was based on exploiting the video surveillance public network of a place of interest in order to gather up-to-date videos of the current state of the streets. Due to the prohibitive amount of data and to their typology, artificial intelligence algorithms, particularly Convolutional Neural Networks, were adopted. Indeed their suitability to give fast results according to input data was of paramount importance to give prompt answers regarding the potential risks a user could face during its route to a final destination.

2 Experiments

The classification features were performed by using the aforementioned algorithms, particularly the employment of Convolutional Neural Networks.
Neural Network engineering: The CNN adopted was designed starting from the Inception V3 architecture [9]. The bulk of the network was trained on the ImageNet dataset [10]. The final fully connected layers of the network were trained with the Violent-Flows-Crowd [11][12]. The resulting classification output is a score in the range [0,1], with "crowded" attribute belonging to the range [0,0.5] and "not crowded" attribute to the range (0.5,1].
Datasets: The bulk of the Inception V3 inspired CNN was trained on the ImageNet dataset. The final layers of the CNN were trained on the Violent-Flows-Crowd dataset. This dataset was preprocessed in order to obtain all the videos with the same number of frames.
Front-end development: The second phase of the project consisted on designing the front-end apparatus of an application that would respond to the following needs: a navigation system to be questioned about the route to reach a specific destination. A clear and easy-to-use list of all possible routes and vehicles needed to reach the destination. A real time updating system that would dynamically alert the customer about changing on the profile of risk, i.e. some transportation system or some location could be occupied by a prohibitive amount of other users.

3 Execution and results

In the context of usability and human-computer-interaction the system should also be able to be personalized with respect to the specific users, i.e. adapting to its health condition or other specific needs whose satisfaction would result in an overall increment of its wellness. Additionally it should be designed to interact in a seamless and natural way in order to provide a human-like experience. Finally, it should be able to dynamically change with respect to the users' needs and changes of habits over time, without losing the fundamental objective of providing wellness and safety. The front-end development was performed mostly on the readability aspect, with particular attention to the requirement of a natural communication pattern. The main functionalities of the application were developed, i.e. the navigation system with the alert system and the priority matching of the best routes in terms of safety and specific needs of the customer. Once the AI algorithms were trained and the feasibility of the process was verified, the system was applied on a set of videos gathered from the video surveillance system of a location of interest. The process resulted in obtaining an up-to-date indicator of how much "crowdy" the areas under analysis are. The classification process was performed constantly in order to get multiple outcomes of the same areas. The results for each location were averaged in time in order to get a robust evaluation of the "crowded" attribute of the place. Once applied to real world videos, the Inception V3 based Convolutional neural network had a performance above the 70% on recognizing

risky situations, i.e. the presence of dangerous clusters of people in the same place. In order to compute the accuracy, 3 real world videos on pedestrian locations were manually labeled with respect to a scale of gravity (very crowded, crowded, not crowded) in terms of how much crowd a place is on each photogram. When employed over time, this accuracy has proved to be sufficient to classify a set of points of interest with respect to the likelihood of being exposed to the presence of other subjects in small areas, i.e. under the minimal safety distance. The overall technology was installed into a user-friendly application able to be easily set-up for the basic customer needs. A prototype of a hypothetical application for the user assistance on a specific topic (navigation system) was developed. The project shall be located into a broader perspective, i.e. an ensemble of services designed to assist the user in a broader series of needs in the context of smart cities. An interesting following development would be to manage the available routes of the end users in order to distribute the traffic while minimizing dangerous agglomerates of people.

References

1. Lo, F. Y., & Campos, N. (2018). Blending Internet-of-Things (IoT) solutions into relationship marketing strategies. *Technological Forecasting and Social Change*, *137*, 10-18.
2. Van Kranenburg, R., & Bassi, A. (2012). IoT challenges. *Communications in Mobile Computing*, *1*(1), 1-5.
3. Nuamah, J., & Seong, Y. (2017, June). Human machine interface in the Internet of Things (IoT). In *2017 12th System of Systems Engineering Conference (SoSE)* (pp. 1-6). IEEE.
4. Zalewski, J. (2019). IoT Safety: State of the Art. *IT Professional*, *21*(1), 16-20.
5. Straker, L., & Pollock, C. (2005). Optimizing the interaction of children with information and communication technologies. *Ergonomics*, *48*(5), 506-521.
6. Parker, C., Caldwell, G. A., & Fredericks, J. (2019, December). The Impact of Hyperconnectedness on Urban HCI: Challenges and Opportunities. In Proceedings of the 31st Australian Conference on Human-Computer-Interaction (pp. 480-484).
7. Farkas, P. (2015, August). Defining HCI/UX Principles for Urban Environment. In *International Conference of Design, User Experience, and Usability* (pp. 346-356). Springer, Cham.
8. Zhou, Y., & Jiang, N. (2018, July). The research and co-creation model for urban interaction design and practices. In *International Conference on Cross-Cultural Design* (pp. 444-454). Springer, Cham.
9. Szegedy, C., Vanhoucke, V., Ioffe, S., Shlens, J., & Wojna, Z. (2016). Rethinking the inception architecture for computer vision. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 2818-2826).
10. Deng, J., Dong, W., Socher, R., Li, L.-J., Li, K., & Fei-Fei, L. (2009). Imagenet: A large-scale hierarchical image database. In *2009 IEEE conference on computer vision and pattern recognition* (pp. 248–255).
11. Hassner, T., Itcher, Y., & Kliper-Gross, O. (2012, June). Violent flows: Real-time detection of violent crowd behavior. In *2012 IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops* (pp. 1-6). IEEE.
12. Sumon, S. A., Shahria, M. T., Goni, M. R., Hasan, N., Almarufuzzaman, A. M., & Rahman, R. M. (2019, April). Violent crowd flow detection using deep learning. In *Asian Conference on Intelligent Information and Database Systems* (pp. 613-625). Springer, Cham.