COVID19: Confinement Control based on a New Discrete Localization Algorithm (DLA)

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Abstract: Mobile apps have potential to reinforce contact- tracing policies to cover and reverse the spread of COVID-19. However, the majority of applications are based on the use of GPS, which have limitations linked to the violation of data privacy. This finding is strongly refused by human rights NGOs. In this context, we propose a concrete and operational digital solution related to epidemics including Covid-19, which is today the highest international priority. This solution based on Discrete Localization Algorithm (DLA) is a complete and legal intelligent solution to automate containment control and the deconfinement processes.

1 INTRODUCTION

The first case of the Corona virus epidemic (COVID-19) procured in China (Wu, 2020), started at the end of 2019 and quickly dispersed to the whole word.

Indeed, the mortality rate of Covid-19 is not as high as that of MERS or SARS. However, it is a novel virus with no effective cures or vaccines, which can disrupt the public health systems. Moreover, most Covid-19 patients in modest parts of the population have to battle with severe pneumonia without crucial life support, and thus leading to much higher fatality rates (Ferguson, 2020).

Over the world, to curb the outbreak and stop the spread of COVID-19, national governments particularly implemented two approaches. The first approach included rigorous social distancing measures, such as the national lockdown (closing down of schools, public places, closure of non-essential commercial and industrial activities and a ban on non-essential traveling). The main goal of this strategy was to reduce contact between all types of persons and subsequently control the reproduction number R0, which is the average number of persons affected by an infectious person. This methodology was thoroughly implemented by China, effectively conquering the epidemic in a couple of months, and the method was thereafter adopted by most Western countries. However, there has been no reports on the strategies to implement after the Pandemic is tamed, which leaves most of the population still vulnerable to the virus and thus prone to a second wave of virus propagation.

The second approach is mitigation: The idea is to focus on slowing rather than stopping the spread of the epidemic, leading to herd immunity, while controlling it by protecting those at most risk of serious illness from infection, in a way that ensures the continuity of the public health system. This approach initially spearheaded by (Hunter, 2020), has been adopted by the UK government, which later changed the strategy to transmission suppression after the public release of the 9th related report from Imperial College London (Ferguson, 2020).

Truly, other measures and procedures can be used to control the mentioned index R0. For instance, the use of digital and special mobile applications in combating COVID-19 has been largely discussed and suggested. These apps are designed to help contact tracing and identifying persons in response to the COVID-19 pandemic. In this perspective, several applications were suggested, with official government support in some countries. Several states recognize that the value of such apps needs to be considered within the context of wider public health measures and the stage of the spread of the infection. These mobile applications seem to be very interesting as they can help in identifying the infected persons, contact tracing and averting, symptoms checking and contact notification contacts etc.

Since the beginning of the COVID-19 pandemic, many smartphone apps have been developed, some of them by public authorities. Moreover, the World Health Organization (WHO) is working on an application that can provide medically- approved information and inform the users based on their symptoms (WHO, 2020). This standalone application comes besides the WhatsApp-based messaging (WHO, August 2020).

However, the Covid-19 mobile apps must have full compliance and ensure privacy legislation and data protection. These Privacy worries have been raised, especially about systems that are established on tracking the geographical location of application users. A of lot of measurements are taken to deal with such problems, like the use of the anonymized data, which does not consist of storing data in centralized databases...

In the case of Morocco, the police have been using a mobile application to follow on individuals that do not respect the travel restrictions imposed to fight Covid-19. With the same objective, we propose in this study a new efficient system for controlling the COVID-19 pandemic. This digital system is based on a mathematical formalism to ensure confinement control while respecting privacy data protection. This solution can widely control the R0 parameter by controlling the citizens mobility.

As presented in the following sections of this paper, the proposed system uses a new concept called the Discrete Localization Algorithm (DLA) and can help to widely control R0 index with data protection.

The main objective of our system is twofold. On one hand, it targets the authorization strategy control and congestion suppression by automatically generating authorizations to go out of the house or those delivered by the job office with respect of the data privacy. On the other hand, the system targets data census by collecting information on people's mobility and compliance to confinement rules. Our system therefore solves problems related to the time delays in the measurements and control of the R0 parameter.

This study presents Graph theory and Minimum Spanning Tree algorithm as well as details on the Discrete Localization Algorithm (DLA), including simulations.

2 GRAPH THEORY AND MINIMUM SPANNING TREE

Our approach is based on graph theory and minimum spanning tree. Thus, each city (region or country) can be rep- resented by its corresponding undirected and connected graph G(B; E) where B is the set of vertices (nodes) representing different police control point, and E is the set of links between nodes (itineraries). Each vertex of B is indicated by an index i € 1, ..., N. e_{ij} identifies the edge between the nodes B_i and B_j as represented in figure 1.

For the connected graph G (B; E), the minimum spanning tree (MST) problem is focused on finding a spanning tree with minimum total edge weight. This problem has been widely considered and is a sub-problem of many known network problems. Its applicable in wireless networks and VLSI design (AFP, 2020), (Tseng, 1998), (Zheng, 1996) and many graph problems such as connectivity checking (Maon, 1986), (Tarjan, 1985). It is also used on ovarian and bronchial cancer detection and various other medical analyses (Brinkhuis, 1997), and network evolvement (Matos, 2002).

Boruvka, Kruskal, and Prim algorithms provide a large number of the known algorithms. Since Kruskals algorithm works on arranged edges and MST edges are likely to be among the θ(nlog(n)) smallest weight edges, partial sorting of edges work greatly to find out lighter edges (Brennan, 1982), (Paredes, 2006).

Filtering of edges connecting nodes makes the algorithm very faster (Kershenbaum ,1972).

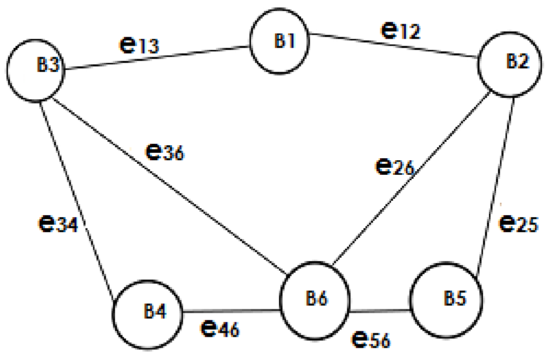

Figure 1: An example illustrating an undirected graph

In addition, Bucket sorting on edges is employed in Kruskal's algorithm which performs greatly for uniformly distributed random edge weights (Katajainen, 1983).

A recently devised Filter-Kruskal algorithm has a higher performance over a wide range of input types (Osipov, 2009). Edge Pruned Minimum Spanning Tree (EPMST) algorithm uses the benefits of Kruskal's and Prims algorithms. As Kruskal's algorithm performs better on sparse graphs and produces a minimum spanning forest, EPMST filters out a large number of edges before running the Kruskal's algorithm. Then it runs Prims algorithm on a compact dense graph. Selection of pivot value is a major concern on the EPMST (Mamun, 2016).

3 GRAPH THEORY AND MINIMUM SPANNING TREE

The objective of this part is to define the relation between controlled geographic space by the local authorities and graph theory. In addition, we present the DLA algorithm to control the confinement. Using the graph theory and the Minimum spanning Tree we can define:

- Identification of the authorized area As: For each displacement, an authorized area As is generated. It's based on the source and destination positions and on the tolerated space by the authorities. This area is computed using Edge Pruned Minimum Spanning Tree (EPMST) algorithm, which has a superior performance relative to the best-known algorithms especially when the graph is not very sparse (Mamun, 2016). Moreover, EPMST algorithm (Mamun, 2016) is also used to select the shortest path and the tolerated space by the authorities. Any control by the agents of authorities inside the authorized zone will be accepted and validated, except if there the estimated duration for the displacement is not exceeded. In addition, if the check is carried outside this zone, the application automatically generates police fine. The figure 2 shows a simulated graph highlighting the departure and the arrival points demanded by the user. The city is a 50km2 square with 50 control stations represented as a network. Figure 3 represents the shortest path between the source and destination. This path is used to compute the time duration authorised for the displacement if the control stations are identified by a number or a specific value. Figure 4 presents in addition to the shortest path, the control station identifications. Figure 6 resumes the ADL solution based on the EPMST. It shows the connected graph, the minimum weight spanning tree and the shortest path. The Figure 5 illustrates a simulated graph highlighting the shortest path between the departure and the arrival points and the control stations identified by values (codes). Besides, Figure 6 shows in addition to the shortest path, the authorized space for the concerned displacement. This space is indicated by the nodes and paths in pink color. Indeed, each control by authorities in this region gives an accepted permission.

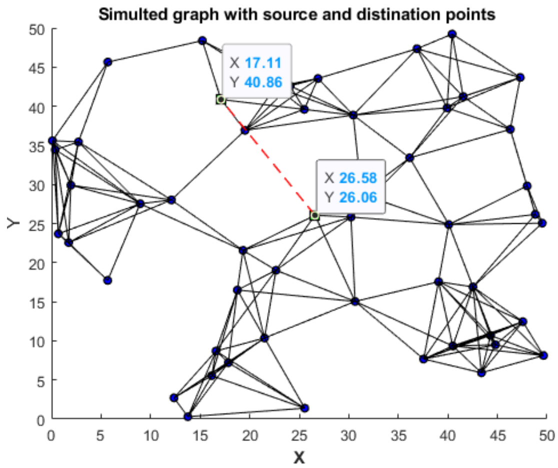

Figure 2: Simulated graph highlighting the departure and arrival points

- Computation of the duration of the displacement: Our system also computes the displacement duration based on the shortest path. In this study and to simplify the process, we used the mean duration of all paths from source to destination.

The equation 1 represents this duration as:

$$Td_1 = \frac{1}{j}\sum_{i=1}^{j} t_i \quad (1)$$

Where t_i represents the source and destination. The parameter j represents the total number of possible paths without loops.

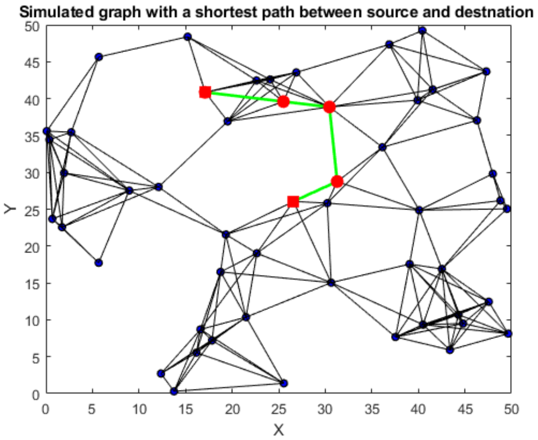

Figure 3: A Simulated graph with the shortest path between source and destination points, 50 control station and 50x50 square region

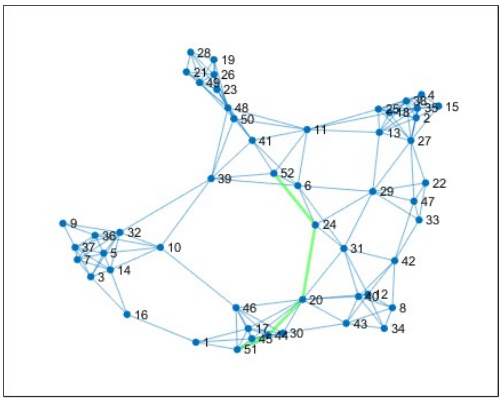

Figure 4: Simulated graph the node identifiers and the shortest path

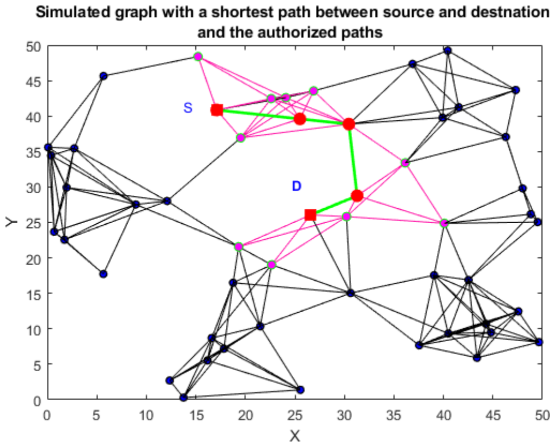

Figure 5: Simulated graph highlighting the short paths and the authorized area

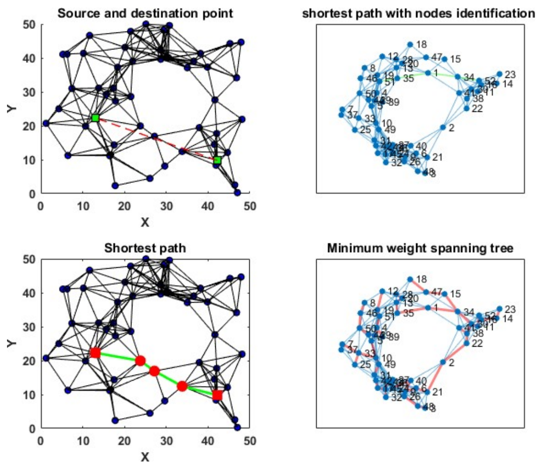

Figure 6: Simulated graph highlighting the minimum weight spanning tree and the shortest path

4 SALAMATI APPLICATION BASED ON THE DLA, SIMULATION AND RESULTS

All citizens must download and correctly install the SALAMATI Application (Figure 7) from the internet space reserved for this operation. A person going out for different reasons (to work, shop, or buy medicine) must authenticate and identify the destination. The authentication is based on the National Identity Code (NIC) (CIN in the case of Morocco) which is largely sufficient to identify all persons. The application generates a QR code for each service request.

This code will be used for each control by the police or authorities. The user can switch-off their internet connection and only use the QR code generated by the SALAMATI Application. This code contains three types of data:

- User Identification
- The authorized area
- Duration of the displacement.

For the control, while respecting social and physical distance, the person presents the QR code to the agent and the latter can then validate the real position or not. The reader displays the NIC and two different colors; green for approbation and red for no authorization. The figures 8 and 9 show QR codes generated by the SALAMATI Application and two different responses for two different controls. The first is rejected whereas the second is validated. The agent must install the application SALAMATI for lecture and control. In principle, internet connection is not necessary, but can be used for centralizing data and giving information about people's mobility compliance to confinement. In addition, this parameter will be used for different uses, especially in finding the relation between mobility and the R0 parameter.

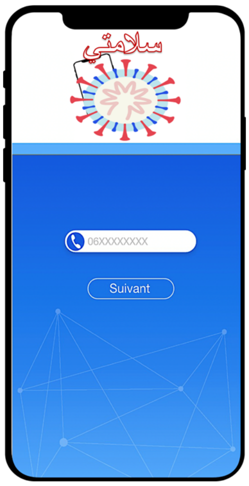

Figure 7: SALAMATI Application

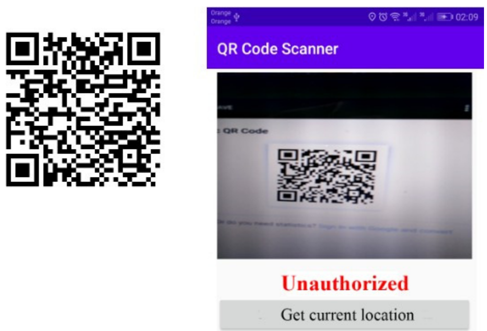

Figure 8: A non-authorized scanned localization

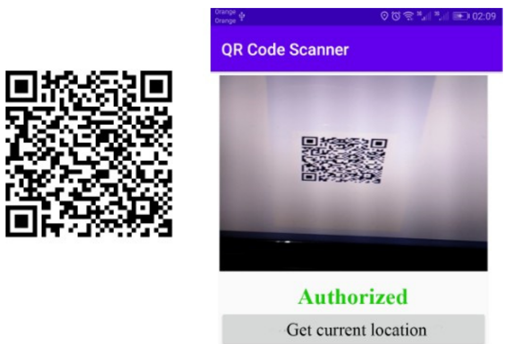

Figure 9: An authorized scanned localization

5 CONCLUSION

In this paper we propose a new approach to deal with data privacy in the case of the confinement control. This solution overcomes the limitations linked to the violation of data privacy. We proposed a concrete and operational digital solution to fight epidemics including Covid-19, which is today the highest international priority, based on a theoretical and practical solution. Indeed, the SALAMATI mobile application is based on the Discrete Localization Algorithm (DLA) which is a complete and legal intelligent solution to automate confinement control processes and the progressive easing of lockdown by controlling the displacement of citizens and the area for which the authorization was delivered. The SALAMATI mobile application is based on the QR code solution identifying three parameters: a) User Identification, b) The authorized area and c) Duration of the displacement.

In the perspective works, we will measure time computation and solve the congestion problem using the SALAMATI mobile Application.

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