Border Management Systems: How Can They Help Against Pandemics

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\textbf{Abstract}. The presented work proposes ways that modern and upcoming border management systems can be utilized to help the authorities mitigate the spread of infectious diseases. This work was inspired by the latest COVID-19 pandemic that spread all around the world forcing governments to apply restrictions and bans on international travels. The paper presents the case of how the border management solution proposed and extended by the H2020 projects SMILE and ITFLOWS respectively, can be utilized to (i) allow the travellers to make a self-assessment before their travel, (ii) be notified of potential health-related alerts at their destination or transit and (iii) provide to the border authorities advanced information on the travel history of each passenger allowing them to better and faster assess their entry or exit of a country. To the best of the authors’ knowledge, the proposed methods are not yet implemented in any border management system and would provide a valuable mean to help mitigate a pandemic from spreading.

\textbf{Keywords}: Border management · Biometrics · E-health · Border checks · Public health

\section{Introduction}

The introduction of recent pandemics such as Covid-19, Zika, SARS and H1N1 prove the necessity of coping mechanisms that mitigate their spread and reduce the sweeping consequences they may have on affected populations. The severity of such situations and their effect on the lives, health, psychology, and economy has led to an increasing scientific interest and prolific literature regarding epidemic modelling, optimization, and control.

Restrictions of human activities have been utilized as a drastic countermeasure for disease spread mitigation, nevertheless their extensive use can have huge economic and societal consequences. Therefore, purposeful strategies that minimize the spread of infection with the least possible sacrifices are deployed. The World Health Organization (WHO) considers cross-border interactions a determining factor that characterizes a
country’s readiness to cope with a health or biological emergency, such as a pandemic [1]. Hence, border control is considered a vital measure against pandemics, especially during the emerging of the outbreaks, since it prevents the spread between different countries and populations [2, 3]. In the Schengen Border Code of the European Union, if checks conclude that an individual poses a threat to the public health, it may not be admitted to the country. Until latest pandemics this condition of entry and stay was merely an administrative filter for people arriving from countries with underdeveloped health systems and basically meant the requirements of presenting their vaccination booklet.

This paper presents an effort to accommodate an H2020 project that developed a border control system, namely SMILE (Smart mobILity at the European land borders), to the additional requirements occurring for border crossing during pandemic situations. Until now, SMILE’s aim is to leverage border control through mobile applications that ensure trusted and secure authentication through biometric control, while enabling faster control procedures, providing to the travellers the capability to declare their trip in advance (similar to the air borders using Advance Passenger Information and/or Passenger Name Records for long time). In this paper, supplementary features that can be easily incorporated to SMILE’s structure and constitute valuable assets to border control during pandemics are proposed. The suggested features include communication of the problem and any requested measures that a traveller should be aware of before their departure, accelerated and safer border control procedures by submitting in advance recent health and travel history, preparedness of border control officers to cope with suspicious cases. To our knowledge, there is no other system offering such thorough support for border control that includes both common security control and health control in regard to pandemics. It is especially important however, to ensure the proportionality between requested health data and the actual pandemic threat, as personal health data is a sensitive personal data. SMILE is capable to dynamically follow these requirements, changing requested data and allocated risk indicators by country or by time period according to actual decisions of policymakers.

The remainder of the paper is organized as follows. Section 2 describes related work regarding border control systems and technologies utilized to cope with pandemics. In Sect. 3, the SMILE system is presented while updates that can leverage it to a tool for health border control during outbreaks are introduced. In Sect. 4, the application scenarios for the updated system are analysed while examples depicting the new features of SMILE’s applications are provided in Sect. 5. Finally, the paper concludes in Sect. 6.

2 Related Work

Related work is divided in two subsections in order to cover the topic on measures and technologies developed to handle pandemic situations but also to describe existing border control systems.

2.1 Technologies and Measures for Pandemic Situations

Due to their deep impact on humanity, pandemics have gained scientists interest. Literature covers tools that calculate the outbreaks’ spread, measures that mitigate them
and technological tools aiming at informing the public on the situation and facilitate them to recognize possible symptoms. The existence of large-scale datasets [1, 2] providing information on pandemics’ spread has facilitated the study of network topology, meta-population and disease diffusion models and patterns [4–6]. Furthermore, computational and visualization tools made their appearance so as to provide accurate spread predictions and the capability of measuring the impact of control strategies [7, 8]. Moreover, mobile applications are developed in order to gather data on social interactions and predict the progress of a contagious disease [9, 10].

Multiple measures are deployed at borders for pandemic mitigation. Their goal is to inform travellers on the pandemic, filter suspected cases, detect the infected ones, manage them and probably apply a health follow up [11–13]. In this scope, usual tactics are entry screening with thermal scanners, self-reporting of travellers on health and travel history, further lab tests on symptomatic cases, quarantine and health follow up by means of telecommunication.

A very powerful strategy against the pandemic spread is proven to be the communication of the problem, by providing notices on disease outbreaks to the travellers, information on practices that will help them to protect their health, legislations and rules of the country to be visited regarding ongoing pandemics. In [14], the effect of the information is considered to be more effective and valuable than entry screening with thermal sensors, highlighting its importance. Various ways of communications have been utilized until now; from leaflets, posters and informational videos to announcements to social media, mobile apps [15, 16] and websites such as the Center’s for Disease Control (CDC) website [17]. In this site, travel notices on disease outbreaks are posted and each notice is assigned with a risk level while for each country there is specified information on contagious diseases, ways to protect oneself and vaccines that are needed depending on the visit duration. Furthermore, personalized traveller notifications based on criteria such as age, pregnancy, immune compromise, and chronic disease are provided. Furthermore, apps like Mo-Buzz and Mozify [15, 16] provide real-time worldwide news on a specific disease (dengue), have educational videos, dynamic hotspot maps and symptoms checker.

2.2 Border Control Systems

There are several mechanisms for exchanging information in European border management cooperation. In recent years, the EU has sought to implement new technologies and develop large-scale IT systems to improve the tools already in use. They allow European authorities throughout the Schengen area to make efficient use of and use the data required to perform their tasks. The European Agency eu-LISA has major role for the operational management of large-scale IT systems. Eu-LISA actively supports and promotes effective cooperation and ex-change of information between EU law enforcement authorities, ensuring the uninterrupted operation of large-scale IT systems, thereby contributing to the free movement of persons within and across the Schengen area. The Agency currently manages EURODAC, the Visa Information System (VIS) and the second-generation Schengen Information System (SIS II). The SIS II database enables the exchange of information on criminal matters in order to ensure a coordinated investigation of offenses that no longer respect national borders. The VIS ensures fair, efficient
and secure processing of procedures for applying for visas and foreign visitors to the EU, while the Eurodac system allows for the monitoring of asylum applications, submitted by those protected under EU values and norms. In addition, both the Europol Information System (EIS) and the European Criminal Records Information System (ECRIS) are used in border control mechanisms. These systems are extended with two new systems under introduction process. First is the European Entry-Exit System (EES), recording third country citizens entering and leaving the Schengen Area at EU level instead of the previous individual Member State entry-exit systems such as HERR in Hungary. Second is the European Travel Authorization System (ETIAS), requesting pre-registration from third country citizens before traveling to the EU, similar to existing ESTA in the US or ETA in Canada.

3 Smile System Description

SMILE proposes a novel mobility concept for the accurate verification, automated control, monitoring and optimization of people’s flows at Land Border Crossing Points (BCP), requiring much less infrastructure than traditional border gates with fixed workstations. It leverages the capabilities of the smart mobile devices in biometric control for secure and trusted authentication while enabling faster control procedures. The traveller declares to SMILE’s application the Border Crossing Point (BCP) they are going to visit providing any information that is required for border control procedures and risk analysis based on the traveller’s data. The border check is completed at the BCP by using biometrics to validate the user’s identity.

In particular, two different mobile applications, one for the user and one for the officers at border control, are utilized. The user fills in any required information regarding their identity and their trip. Important documents, such as the identity card, are scanned while biometrics, like facial photos, are provided. The reported trip information notifies the Border Crossing Point (BCP) officers of the travellers’ arrival so that any essential checks in border control systems databases are completed before they reach the border. In this way, travellers are submitted to risk analysis regarding security issues in advance, accelerating control procedures. Once the travellers have reached the border, authorized control officers verify their identity through a designated SMILE application that has access to all the a priori submitted traveller information. Biometric features from the travellers are matched to the submitted ones and further procedures are followed according to related legislation.

SMILE’s structure can easily accommodate to border control needs during pandemics. Based on advanced knowledge of the travel plan, SMILE application can alert travellers on information on the outbreak condition to their destination and any necessary actions they have to take before travelling. Moreover, during registration any additional information required due to pandemics, such as travel history or health symptoms, can be submitted along with the rest data in the registration form. In this way, the authorities at the BCPs have advanced knowledge on cases that require special attention. Furthermore, biometrics that facilitate the detection of symptomatic travellers can be included to the existing ones to provide supplementary assistance to the detection of the suspected cases.
4 Application Scenarios

Border control has proven to be an essential measure against pandemics spread with extreme importance and severity. Travelers visiting different countries might be the reason a contiguous disease enters and infects different populations while people with the intention to visit an infected country should be aware of the disease and the necessary measures to protect themselves. Therefore, a complete border control apparatus for pandemics comprises the intention and the measures to protect both travelers and visited countries.

In this scope, there are two main actors in the border control application scenarios: (i) travelers, and (ii) border authorities. Furthermore, the two major factors that determine the application scenarios are: 1) the state of the country to be visited regarding the pandemic, i.e. if it is already affected or not; 2) the infection status of the country(-ies) the visitor has visited over the affection window. Based on these factors, four application scenarios are analyzed comprising each actor facing the two aforementioned states.

All of those scenarios assume that the corresponding policy has provided a legal basis on processing such sensitive data as a form of response to the pandemic situation and issued proper legal order to travelers making provision of such data compulsory for them. Therefore, the scenarios described in the paper does not include proportionality test or impact assessment related to process of health data and sensitive personal data or restriction of fundamental rights such as a citizen’s right to leave or return.

4.1 Traveller Entering a Country with a Health-Related Alert

During the pre-registration stage, a traveler will enter his/her origin and destination countries, along with any transit countries. In case of a health-related alert or ban of entrance in any of the countries to be visited or transit, the system sends a notification to the traveler providing information on the nature of the alert as well as the level of the security alert (according to CDC there are 3 levels: (1) usual precautions, (2) alert for enhanced precautions, (3) warning to avoid nonessential travel). Moreover, further instructions for actions required or suggested for a health wise safer trip are provided. For example, necessary vaccinations or tests required for admission to destination countries are listed, while more personalized information on precautions also provided, such as supplementary measures in cases of pregnancy or underage children can be offered.

4.2 Traveller Exiting a Country with a Health-Related Alert

In cases where a traveler comes from an infected country or when there is an outbreak at one of the transit countries of their trip, the application offers them the opportunity to do a self-assessment of their condition. Hence, a questionnaire where the travelers report their symptoms and any possible contact they had with infected persons is provided. This allows the travelers to acknowledge their situation, take measures, and even postpone their trip if possible and necessary. Moreover, an additional benefit is that, by providing a priori their health history, border checks can be accelerated.

Another service provided by the application, in the case a traveler comes from an infected country, is to provide notifications on the policies applied by the destination
country regarding the pandemic. Such examples may be a quarantine for a certain period, required health tests before entering the country, the provision of healthcare in case the traveller’s symptoms suggest infection etc.

4.3 Border Control to Mitigate Pandemic Entering a Country

The existence of an application that allows a traveller to notify the border authorities of their arrival and provide a priori the required information, such as health and travel history, facilitates and accelerates the border control. In this way, authorities have advanced knowledge that travellers from affected countries arrive at particular BCPs while they are notified on the existence of any suspicious symptoms. Furthermore, in cases that a traveller has already crossed other BCPs, they can be notified on the control checks and their remarks on the specific traveller. Hence, once the traveller reaches the border, the officers have already made a risk analysis based on the reported statements and facts. Cases that indicate possible infection are treated with special attention following the anticipated procedures as they are defined by each country’s legislation. In addition, procedures regarding travellers of low infection risk can be accelerated.

Another measure adopted during outbreaks is the use of unobtrusive means that acquire soft biometrics related to the pandemic’s symptoms. Since fever is usually a symptom in pandemics two widely used means are thermal cameras and infrared thermometers. Therefore, border control can utilize thermal cameras in travellers’ passages, so that the authorities are alerted when higher body temperatures are detected while non-contact thermometers can provide more accurate results in detected cases or in high-risk travellers regarding their travel and health history.

4.4 Border Control to Mitigate PandemicExiting a Country

Although it is not a common tactic, WHO suggests border control for detection of infected or suspicious cases at BCPs while travellers exit a country, especially in cases that multiple people are going to use a common transport mean, such as airplane, train or bus. The technical procedures are common with the checks made while travellers enter a country.

5 SMILE Examples

In this section, several examples depicting the adjustments that can transform SMILE apparatus into a powerful tool for border control during pandemic situations are analysed. The presented examples are based on use cases that occur from the application scenarios and their goal is to further clarify the adaptability of SMILE to the new pandemic scenarios and to highlight the easiness of the application use for the travellers.

5.1 SMILE Traveller Application

The registration to SMILE application requires filling a form with identity data, providing biometric data, such as close face photos, and information on the user’s trip (BCP’s to
be crossed, approximate time schedule, data of the vehicle to be utilized etc.). In cases that the country of departure is affected from a pandemic, the application displays a supplementary form to be filled with questions regarding the appearance of symptoms related to the pandemic and recent travel history (Fig. 2).

In cases that the destination or transit countries are affected, the application alerts the user on the situation by displayed messages (Figs. 3 and 4). Apart from the appearance of the outbreak, the messages include information on bans and important legislations regarding the pandemic (e.g. a potential quarantine that will be applied to travellers in when entering specific countries). Moreover, the users can have access to useful instructions they should be aware of before beginning their trip, e.g. required vaccinations or tests (Fig. 5). Since the gender and the age of the traveller is submitted to SMILE’s system, personalized information can be displayed as well. For example, the application could display specific measures required for pregnant women or underage children.

5.2 SMILE BCPs’ System

Since the user provides a priori information on the trip and answers a questioner on their recent health history and symptoms, a risk analysis regarding the pandemic can be made by the SMILE’s BCP system. In the SMILE’s application for the BCP officer, the officer has a clear view of the travellers that are expected over the next time period at the BCP of his/her interest along with their risk profiles (Fig. 6). For each traveller, the officer can have access to more detailed information (Fig. 7). The results of the analysis can be displayed to the SMILE application that is implemented to be used by
the authorized control officers. The officer, among other issues that require risk analysis, such as criminal activities, can be informed on the risk level of a traveller regarding the pandemic (Fig. 8). In this way, the officer knows in advance when suspicious cases are arriving at the BCP so that extensive control can be applied. Moreover, cases that have passed the control in other BCPs in a recent time period and the results of the control can be acknowledged to the designated officers (Fig. 9).

Moreover, SMILE system can provide a more thorough examination for symptoms using soft biometrics. Since a very common symptom of pandemics is fever, thermal cameras and infrared thermometers can facilitate SMILE officers to detect suspicious cases. Therefore, thermal cameras can be used to travellers’ passages to detect high body temperatures even in cases that were not analysed as high-risk travellers. On the other hand, infrared thermometers can measure the temperature of random travellers, travellers that were indicated by the thermal cameras or travellers that were evaluated

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[Fig. 3. Alert for transit country](#)

[Fig. 4. Ban of travel alert](#)

[Fig. 5. Vaccinations and Medicines required for travel](#)

[Fig. 6. List of expected travellers](#)

[Fig. 7. Traveller profile](#)
as of high-risk by SMILE system. Depending on the measurements and the risk level reported by SMILE system additional measures and procedures (e.g. tests for the disease or quarantine) are followed according to each country legislation. The control results are reported to SMILE officers’ application so that they are available to other BCPs in case the traveller is intending to cross them.

6 Conclusions

This paper presents an effort to accommodate SMILE border control system to the additional requirements occurring for border crossing during pandemic situations. SMILE’s structure provides the capability of information exchange between the travellers and the border control authorities in advance of their arrival at the border crossing point. Based on this feature, extra functionalities that can be proved critical during pandemics can be easily added to SMILE’s mobile applications. Therefore, information on the disease’s spread, the measures taken at each country, the required procedures to bulletproof the one’s health via vaccines and tests can be notified to the travellers before their departure providing them the time to prepare themselves appropriately. Moreover, border officers can be a priori aware of the arrival of travellers with suspicious symptoms and travel history and conduct a risk analysis in advance, achieving accelerated control procedures and increased preparedness to cope with infected travellers.

Another feature of SMILE is the use of soft biometrics and their integration to the mobile applications to facilitate the user identification. In this sense, biometrics indicative of a human’s health, such as body temperature, can be easily incorporated to SMILE’s application in order to make a better evaluation of the travellers’ health condition.

The goal of this paper is to demonstrate ways that SMILE border control system can easily adjust, due to its structure, to pandemic situations. The presented use cases show that both travellers and authorities can benefit from the proposed additional features that accelerate border procedures, improve the evaluation and the detection of suspected cases and provide valuable information to travellers to achieve a safer and more organized trip.

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