Contribution ID: **18** Type: **Paper presentation**

Stamina - Assistive Technology platform for pandemic prediction and crisis management

Friday 5 November 2021 09:20 (20 minutes)

Abstract—Crisis management can be defined as how an organization, or worldwide society, deals with an unexpected event that threatens to harm or even destroy it. The management of a crisis can be split into three phases: pre-crisis, where prevention activities take place; crisis response, in which the management sector has to deal with the problem; and post-crisis, where people try to come back to what they knew as an everyday life before the appearance of the crisis. Over the years, the healthcare domain has been dealing with various epidemiological cases (measles outbreaks in 2018, Influenza during 2018-2019, H1N1 pandemic crisis, etc.) having different levels of complexity. Internet of Things (IoT) solutions such as wearables, real-time analysis using smart systems have been developed to improve the patients' experience when in need and doctors' performance in the field. Still, very few complete systems for decision support, pandemic prediction, and management that connect people from different countries are available. STAMINA will deliver an intelligent decision support toolset for pandemic-related real-life situations, covering most healthcare systems' gaps. In the development process, STAMINA will use a combination of pre-existing technology not currently used by health emergency planners in their daily practice of pandemics management. The method involves gathering data to predict potential threats, assess the impact on financial and societal levels, and recommend mitigation actions.

Index Terms—healthcare, crisis management, pandemic, Internet of Things (IoT), early warning platform

INTRODUCTION

The demand for decision support systems for pandemic prediction and management in the human healthcare domain has increased due to the effects [1] of the Coronavirus disease 2019 (COVID-19). Significant deficiencies regarding countries' epidemic preparedness have been observed since the pandemic has started.

In this scope, the continuous evolution of the Internet of Things (IoT) solutions can improve the healthcare analysis and treatments regarding various diseases [2] by speeding the process and decreasing the amount of work for healthcare staff members (doctors, nurses, etc.). In return, the worker's stress level will decrease, the efficiency will increase because of the reduced number of daily tasks, and the mental health disorders among patients and healthcare staff will be prevented [3].

The Internet of Medical Things (IoMT) includes sensors and smart applications [4] that can examine the patients' condition and give feedback in real-time [5], supporting decision making and even collecting the healthcare parameters for future observations. The issue of an efficient early warning system for epidemiological diseases symptoms started to be of great interest in researchers' activities, primarily because of the benefits it can bring to the healthcare system and society. Biosensing systems are used in early notification and diagnosis approaches for faster detection of various diseases [6].

Collaborative crisis management tools play an essential role in consolidating country-to-country communication by creating solid relationships from which faster response strategies will arise. Furthermore, critical threats and challenges for each sector could be overcome through collaborative risk analysis and early planning [7].

This paper will present the STAMINA solution, which addresses all the improvements mentioned above, needed for better results in dealing with health emergencies (Influenza, SARS-CoV-2, Measles, West Nile Virus, etc.). The STAMINA toolset will include: real-time analysis of web and social media pages, wearable devices (portable diagnostic included), predictive modeling of a pandemic outbreak and its impact (along with decision-making support in implementing mitigation strategies), machine learning-based early warning system (ML-based EWS), crisis management tool, and preparedness pandemic training tool. The STAMINA vision has been designed considering the user perspective, with five main objectives: provide stakeholders with novel, easy-to-use software tools that complement EU-level systems; create a set of guidelines and best practices to improve preparedness and response; increase diagnostic capability; enhance cooperation between and within the EU Member States and neighboring countries, and finally, ensure the sustainability of the STAMINA solution [8].

The paper is structured as follows: Section II will analyze existing state-of-the-art, Section III will focus on describing the components, methods, and models of the STAMINA solution, Section IV will present the Romanian pilot requirements and status. Finally, Section V draws the conclusions and envisions future work.

STATE OF THE ART

After the pandemic influenza (H1N1) in 2009, the 2011 Escherichia Coli outbreak in Germany, the Ebola virus in 2014, Zika virus in 2016 and West Nile virus in Southern and Eastern European countries in 2019, the Coro-

navirus pandemic had a massive impact on humanity, forcing scientist and researchers from all over the world to implement innovative solutions in order to help prevent the virus from spreading at such a high rate.
(As mentioned before), STAMINA is currently developing an intelligent decision support tool-set for pandemic prediction and management and is demonstrating its efficiency by practitioners at national and regional levels within and across EU borders. On a similar note, Faculty of Economic Sciences and Business Management from Babes Bolyai University in Cluj has recently developed a research project that proposed a specialized online platform [9] through which the researchers of the university involved in this scientific initiative publish a series of relevant data on the economic impact of the COVID-19 pandemic in the form of interactive infographics, meant to show a comprehensive, updated real-time image of the Romanian economy. The main objective of the project is to provide real support to decision-makers in Romanian politics and economy by carrying out and regularly updating the analysis of the situation generated by the COVID-19 pandemic.
As it has become a common fact that people are not really relying anymore on old-school news sources to inform themselves about the epidemic situation, but rather on the Social Network Service (SNS), an study conducted by the Department of Computer Science and Engineering from Seoul National University of Science and Technology proposes a SNS Big Data Analysis Framework for COVID-19 Outbreak Prediction in Smart Sustainable Healthy City, based on information retrieved from the Twitter platform. The obtained results have demonstrated an outbreak cluster predicted seven days earlier than the confirmed cases. The possibility of analyzing data from SNS platforms enabled the prediction of outbreaks some days earlier, and eventually, the infection rate was reduced [10].
One study [11] conducted in China presents a mortality risk prediction model for COVID-19 (MRPMC) that uses patients'clinical data in order to separate patients into different groups by mortality risk, which allows the prediction of physiological deterioration and death 20 days earlier. This proposed model is based on four machine learning methods including Logistic Regression, Support Vector Machine, Gradient Boosted Decision Tree, and Neural Network. It enables precise mortality risk stratification of patients with COVID-19, and facilitates more responsive health systems that are responsive to critical cases of COVID-19 patients.
Maybe one of the most popular safety measures that was taken in order to reduce the consistent number of COVID-19 cases was lockdown. All over the World, people were advised to stay inside of their home for as long as possible and keep the legal social distance between other people while being out in public. Even though these measures have been shown to considerably reduce the new confirmed cases, an article [12] proposes an objective and quantitative way to monitor population behavior in order to analyze the impact and response of people in COVID-restricted situations. The team of scientists explored the utility of the RADAR-based platform to test the effect and response of lockdowns and social distancing measures aimed at reducing the spread of COVID-19 by interpreting participant data already collected from November 2017 onward as part of the ongoing RADAR-CNS studies. The study concluded with some very relevant results: the team managed to quantify expected changes in time spent at home, distance travelled, and the number of nearby Bluetooth-enabled devices between the period before lockdown and the one during the lockdown. They also noticed reduced face-to-face gatherings and communication as measured through mobility features and increased virtual socialization through the phone, along with some health parameters of patients such as heart rate, which resulted in being not too high, and the chaotic sleep schedules of patients, caused by the tremendous pandemic.
The Coronavirus pandemic was a critical situation for humanity, forcing people everywhere, in a very unpleasant manner, to create new and innovative solutions in order to help not only themselves, but also people in need from all over the globe to successfully defeat the virus.
SNCRR - through the Department for Emergency Situations - consisting of volunteers and employees - is mandated to provide support to the authorities in the process of managing humanitarian crises - of any kind and to intervene to remove their effects. At the same time, SNCRR is mandated to participate in European research projects, encouraging innovation in the organization - and at the same time offering feedback and validation of the concepts of the participating projects. In the last year, SNCRR was also involved in the COVINFORM Project - one of the 23 new research projects funded by the European Commission with a total of 128 million euros to address the coronavirus pandemic and its effects [13].
Policymakers and public health experts unanimously recognise the disproportionate impacts of COVID-19 on vulnerable persons: even in countries with well-developed responses, the outbreak and its repercussions imperil the basic well-being of social groups whose livelihoods are already precarious.
COVINFORM draws upon intersectionality theory and complex systems analysis in an interdisciplinary critique of COVID-19 responses on the levels of government, public health, community, and information and communications. Promising practices are evaluated in target communities through case studies spanning diverse disciplines and vulnerable populations.
The COVINFORM project will: assess COVID-19 responses in a multilevel governance framework and develop an online portal and toolkit for stakeholders in the governmental, public health, and civil society/community domains.

COMPONENTS, METHODS AND MODELS

Infectious diseases have the potential to pose serious threats to public health. Managing this type of crisis remains a serious challenge due to the number of people involved, the different legal, administrative, professional and political cultures, as well as the lack of cross-border crisis management infrastructures.

STAMINA contributes to overcoming these challenges by providing improved decision-making technology for pandemic crisis practitioners at regional, national and European level. The project will focus on two stages of the emergency management cycle: preparedness and response.
This will be possible with the following tools:
Antimicrobial Resistance Model (AIR): currently focuses on the E.coli microbe along with one of its resistance mechanisms called ESBL; will expand its project to present x conditions of multitasking learning model (MTL) architectures to predict output estimates (e.g., number of deaths caused by prolonged symptoms and mortality rates) over a period of time.

Lifelong physical activity modeling and simulation (PALMS): it is used to model the effect of different policy interventions on long-term public health in response to an outbreak of COVID-19 in Valencia. PALMS can be used both independently and in cooperation with the Data Management Harmonization tool and the Common Operational Image (COP) tools;
Dynamic Hospital Management (CHARM): is a discrete event simulation (DES) that models the dynamic reconfiguration of hospital departments for bed capacity planning, facilitating the continuation of normal operations of the Intensive Care Unit (ICU) and epidemics;
FLEE: is an agent-based modeling code that is used to predict migratory movements and will be modified in STAMINA to include the movement of goods; Flee is used to investigate the E.Coli transmission pathway identified in the Netherlands;

The Flu and coronavirus simulator (FACS) models the transmission of SARS-CoV-2 (or other viruses) and stimulates the epidemic of SARS-CoV2 in a given region using the computational dynamics of the disease on a local scale (e.g. city or neighborhood);
BIMS: is a predictive model that simulates the transmission of West Nile virus through the use of agents that represent: the environment, mosquitoes, avian hosts and humans;

Global Epidemic and Mobility Model (GLEAM): is a stochastic tool for modeling meta-population epidemics that allows the simulation of the spatio-temporal spread of various infectious diseases globally, taking into account over 3200 subpopulations from about 230 different countries and territories worldwide;

Machine Learning-Based Early Warning System (EWS): is responsible for processing data received from various other STAMINA tools; it also produces warnings and alerts in the event of deviations from the rules or the identification of models, thus preserving not only the raw data but also the processed data;

Web and Social Media Analysis Tool (WSMA): is an online monitoring and listening tool that collects data from social media APIs based on end-user-defined search parameters;

Preparedness Pandemic Training Tool (PPT): its role is to provide the trainer (or group of trainers) with the opportunity to design a training exercise in a modern graphical user interface and to obtain the exercise scenario in a digital form, easy to edit and share;

Crisis Management Tool (CRISISHUB) has the following roles:
Response planning before a crisis;
Managing information during a crisis;
Making strategic decisions during a crisis;
(Re) allocation of resources during a crisis.
ENGAGE defines, monitors and disseminates in real time the availability of the hospital in terms of number of beds, medical services, etc.;
Common Operational Image (COP) is a web-based software solution that aims to provide different types of views by integrating external tools and data sources.

RO PILOT REQUIREMENTS AND STATUS
In the following part, we will present an example of the evolution of the covid-19 numbers of cases in Bucharest over a determined period (approximately one month).
We used Grafana to realize the analytics and show how the numbers changed by observing the values every two days.

For this graph, we used as a source the time_series_ro_counties_daily.csv file whose structure is described here. These are the steps for creating the final chart:

Create an empty time-series dashboard and select the data source.

At Path, we indicate the file.

At Fields, we indicate the columns of interest and their type.

The graph obtained at this step contains the values for all cities and cannot be interpreted correctly.
Add a Filter data by Value transformation and select the data for Bucharest (iso == B)

The graph is now the desired one, the correct one, with the cases from Bucharest:

As we can see, from the start period to its end, the numbers are increasing.

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The goal of the Romanian pilot is in line with the main objectives of the STAMINA [8] project and wants to
The Web and Social Media Analytics tool (WSMA) is one of the many STAMINA features that are under develop
WSMA will be used for the monitoring of social-media networks, in the first instance for Twitter and Reddi
The WSMA tool has an important role in the STAMINA project as it helps the authorities to understand, at a
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Authorities can create a dashboard in this tool and add specific keywords that they want to monitor for a better understanding of the citizens and their thoughts shared on social media platforms.
A similar sentiment analysis platform was developed in the SoMeDi [14] project, which is a recruitment platform based on Natural Language Processing (NLP) that aims to explore the hidden information of the users (job applicants) regarding specific topics related to the employing company. The modularity of SoMeDi enables the project to provide relevant information about the sentiments of the citizens during this difficult period. STAMINA can build upon SoMeDi and improve the recognition of the feelings experienced by the population by crawling data from social-media APIs, processing the text and saving it into a cloud database for further analysis.
The Faculty of Political Sciences and Business Management from University Babes-Bolyai, Romania has developed a platform [9] that openly presents infographics and relevant data regarding COVID-19 and the economical impact of the pandemic on the romanian economy and some social aspects (children presence in schools, unemployment rate, time spent outside home, attendance to sport events, etc.).
Graphs.ro [15] is a website that collects and analysis public data from reliable sources, providing panels and graphics with COVID-19 informations (no. of cases, deaths, tests, vaccines, etc.) to show a comprehensive view of the pandemic situation in Romania and all the cities.
Code for Romania Association is a NGO that collaborated with the romanian government to develop a website [16] that provides informations and infographics about the pandemic situation in romania, only from official sources, to the concerned citizens and mass-media for a better understanding of the reality and to stop the phenomenon of fake-news.
User-Requirements
The requirements for the WSMA tool are categorized based on their relevance to the end-users in: Mandatory, Important and Interesting.
The mandatory ones are related to understanding public discourse about the pandemic and the responses received, identification of public health threats signals, and detecting societal distrust in pandemic measures and institutions. The important use requirements are considered: understanding the news speech and trends about the pandemics and politics, the integration with the Early Warning System so users will receive real-time alerts about the social-media trends, the detection of fake news that are distributed and the identification of the persons / organizations that are promoting them. Other important user-requirements are represented by the possibility to contextualize the relevance of the information, present the results in categories and in geographical context and to divide social-media users in different categories. As interesting user requirements it was identified the role-specific information that will be distributed based on the importance to specific users, the identification of key pathways for messages and particular keywords to be shared to social-media users, as well as for the tool to provide suggestions for the content and form of the published messages.

CONCLUSIONS AND FUTURE WORK

Various IoT solutions have been developed to enhance medical staff productivity in the healthcare sector during the years, but no complete solutions were noted. In this paper, a work in progress complex platform and its capabilities are described. The toolset will mainly include wearable and portable diagnostic devices, predictive modeling, an early warning system, and a crisis management tool. Together with the other functionalities described in the paper, STAMINA will improve relationships between the countries and increase diagnostic capability by providing tools and creating guidelines to enhance preparedness and response to worldwide crises.
IoT has rapidly entered the healthcare field because of the need for intelligent pandemic tools. The main goal is for most hospitals to access new technologies and proper knowledge to have the ability to use them. For future work, after the solution is finished, the project members will adequately test it to check for possible irregularities. The stakeholder's opinion will continuously be used for further improvements. All the facilities listed above will be implemented in easy-to-do steps to represent an excellent toolset for pandemic crisis management.

REFERENCES

Tavakoli, M., Carriere, J. and Torabi, A. (2020), Robotics, Smart wearable technologies, and autonomous intelligent systems for healthcare during the COVID-19 pandemic: an analysis of the state of the art and future vision. Adv. Intell. Syst., 2: 2000071. https://doi.org/10.1002/aisy.202000071

Greco, L., Percannella, G., Ritrovato, P., Tortorella, F. and Vento, M., 2020. Trends in IoT based solutions for health care: moving AI to the edge. Pattern Recognition Letters, [online] 135, pp.346-353.

Restauri, N. and Sheridan, A., 2020. Burnout and posttraumatic stress disorder in the coronavirus disease 2019 (COVID-19) pandemic: intersection, impact, and interventions. Journal of the American College of Radiology,

17(7), pp.921-926.
Siddiqui, M., 2020. IoMT potential impact in COVID-19: combating a pandemic with innovation. Studies in Computational Intelligence, pp.349-361.
Santamaria, A., De Rango, F., Serianni, A. and Raimondo, P., 2018. A real IoT device deployment for e-health applications under lightweight communication protocols, activity classifier and edge data filtering. Computer Communications, 128, pp.60-73.
Behera, S., et al., 2020. Biosensors in diagnosing COVID-19 and recent development. Sensors International, 1, p.100054.
Abdalla, M., Alarabi, L. and Hendawi, A., 2021. Crisis management art from the risks to the control: a review of methods and directions. Information, 12(1), p.18.
Bonavita I., Maitland E., A trust-motivated framework for assessing governments engagement with citizens on social media, in SocialSens 2021
https://econ.ubbcluj.ro/coronavirus/
Abir EL Azzaoui, Sushil Kumar Singh, Jong Hyuk Park, SNS big data analysis framework for COVID-19 outbreak prediction in smart healthy city, Sustainable Cities and Society, Volume 71, 2021, 102993, ISSN 2210-6707, https://doi.org/10.1016/j.scs.2021.102993.
Gao, Y., et al. Machine learning based early warning system enables accurate mortality risk prediction for COVID-19. Nat Commun 11, 5033 (2020). https://doi.org/10.1038/s41467-020-18684-2
Sun S, et al., Using smartphones and wearable devices to monitor behavioral changes during COVID-19, J Med Internet Res 2020;22(9):e19992, doi: 10.2196/19992
https://www.covinform.eu/consortium/
Pasat A., Suciu G., Birdici A. and Pop I., An internship campaign case study showing results of enhanced recruitment processes using NLP, in Proceedings of International Scientific Conference for eLearning and Software for Education, eLSE 2021, Vol. 2.
Vana, D., 2021. Grafice Covid-19 in Romania.. [online] Graphs.ro. Available at: https://www.graphs.ro/# [Accessed 19 August 2021].
COVID-19: Date La Zi. 2021. Date la zi. [online] Available at: https://datelazi.ro/ [Accessed 19 August 2021].

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Session Classification: Social Aspects of Networking Environment Today

Track Classification: Social Aspects of Networking Environment Today