Scream to Survive(S2S): Intelligent System to Life-Saving in Disasters Relief

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Abstract. Disasters are becoming more and more common around the world, making technology important to guarantee people's lives as much as possible.

One of the most modern advances of recent years is how AI is used in disaster relief. Researchers propose works based on new technologies (IoT, Cloud Computing, Blockchain, etc.) and AI concepts (Machine Learning, Natural Language Processing, etc.). But these concepts are difficult to exploit in low and middle socio-demographic index (SDI) countries, especially as most disasters happen in.

In this paper we propose S2S intelligent system, based on voice recognition to life-saving in disaster relief. Generally, a disaster victim is enable to access to his Smartphone and ask help, with this system, saying "help" will be enough to send automatically alerts to the nearest Emergency Operation Services (EOS).

S2S is composed of two parts: Intelligent application embedded on citizens and victims Smartphones, and S2S System for the Emergency Operation Services.

Keywords: Intelligent system · Voice recognition · Life-saving · Disaster relief

1 Introduction

In countries around the world, natural disasters have been much in the news. Indonesia tsunami in 2004, Wenchuan (China) earthquake in 2008, freezing rain disaster in southern China in 2008, devastating 2011 earthquake in Japan, flood disaster in India in 2013. China severe flood in 2016, 2018 Earthquake and Tsunami in Indonesia and the 2019 tropical cyclone in Mozambique, Zimbabwe and Malawi.

Natural disasters caused by climate change, extreme weather, and aging and poorly designed infrastructure, among other risks, represent a significant risk to human life and communities.

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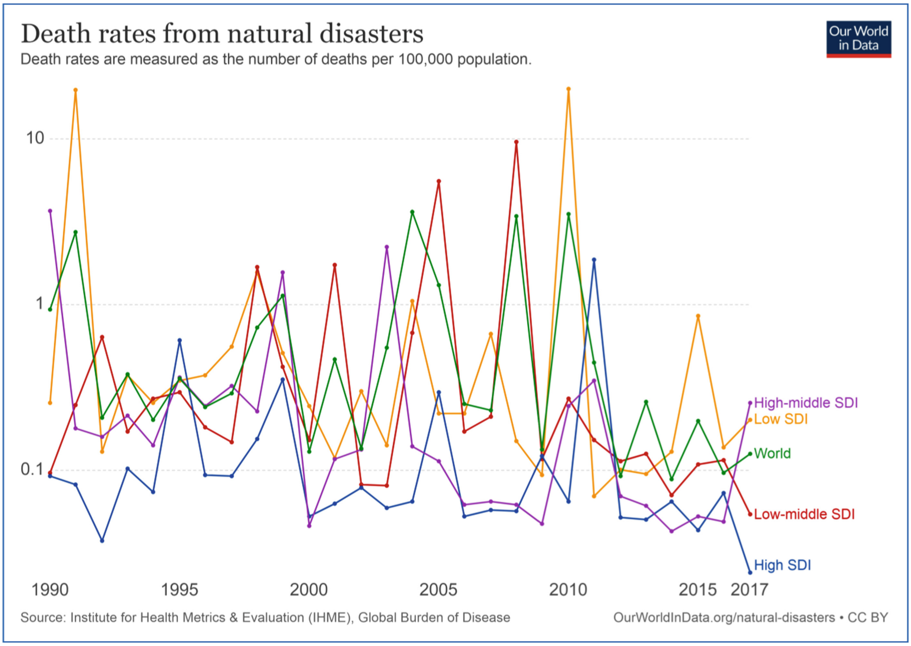


Fig. 1. Link between poverty and deaths from natural disasters (Death rates from natural disasters)

A natural disasters is the encounter between a hazard of natural origin and human, economic or environmental issues. We talk about major risk when the damage and the number of victims are important.

According to the World Health Organization, 160 million people are affected by natural disasters and around 90,000 people are killed every year, [1].

However, with advances in technology, more and more deaths are becoming preventable, encouraging researchers to develop new methods of responding to natural disasters.

Behind this improvement has been the enhancement in living standard and effective response systems. These factors have been driven by an increase in incomes across the world.

What remains true today is that populations in low-income countries, those where a large percentage of the population still live in extreme poverty, or score low on the Human Development Index are more vulnerable to the effects of natural disasters.

We see this effect in the visualization shown in Fig. 1. This chart shows the death rates from natural disasters the number of deaths per 100,000 population of countries grouped by their socio-demographic index (SDI). SDI is a metric of development, where low-SDI denotes countries with low standards of living, [33].

What we see is that the large spikes in death rates occur almost exclusively for countries with a low or low-middle SDI. Highly developed countries are much more resilient to disaster events and therefore have a consistently low death rate from natural disasters.

Note that this does not mean low-income countries have high death tolls from disasters year-to-year: the data here shows that in most years they also have very low death rates. But when low-frequency, high-impact events do occur they are particularly vulnerable to its effects, [33].

Furthermore, the first three days after a natural disaster are the most critical when it comes to saving human life. People trapped on rooftops, under rubble, or in isolated areas need to be found and rescued before they succumb to the effects of the disaster that imperiled them.

For human responders on the ground, this is an almost impossible challenge and what has traditionally made disasters so deadly throughout human history*; "you cannot save people you do not know need help or whom you cannot reach"*, [22].

To deal with these problems, we propose S2S system: Scream to Survive. We used technologies available in middle and low SDI countries to help disaster victims, generally weak and helpless and unable to make call or ask for help in traditional way.

The S2S intelligent system is based on the voice recognition algorithm embedded on the victim Smartphone. That is justified by the fact that an individual in crisis could not be able to signal urgency to intervention team. This is a most helpless situation where affected people need help, but they do not have the ability to look for it.

Furthermore, Smartphone attracts the users and its popularity is increasing in worldwide due to its powerful processing and wireless network capabilities. It enables users to communicate and share information in easily convenient way, [2, 3].

S2S is composed of two parts: Smartphone Intelligent Application installed on citizen Smartphone and intelligent system for Emergency Operation Services (EOS).

Finally, the disaster management consists of four fundamental steps such as mitigation, preparedness, response, and recovery. Among these steps, the emphasis of our work are response and recovery because most of disasters deaths happen in these two steps.

The rest of the paper is organized as follow: Sect. 2 summarizes the related work, based on new technologies. Section 3 presents the proposed system. In Sect. 4 we present implementation concepts, in Sect. 5 we evaluate the S2S performances and Sect. 6 concludes the paper.

2 Related Work

In this section, we will present and discuss disaster management systems based on new technologies and those based on the use of smart phones. The goal is to discuss advantages and inconveniences of each system to motivate our proposition based on the combination of intelligent systems embedded on Smartphone.

(1) **New Technologies for Disasters Management**
Emerging technologies present greater opportunities to make emergency management systems intelligent, protected, and efficient. Today, artificial intelligence (AI), the Internet of Things (IoT), cloud computing and blockchain offer the potential to generate, transmit and read emergency-related data for better decision-making in disasters management, [23].

a. **Blockchain**
Blockchain is in the earliest stages of development, but is a tool that some claim will be transformational for how we transact data. Blockchain is a distributed and immutable digital ledger, secured by cryptography, which can be programmed to record a series of transactions. Its most scalable application today is bitcoin, a cryptocurrency and payment system still growing in its use around the world. A blockchain solution enables the key players/organizations during a disaster management situation to communicate effectively and act on time, [24].

b. **Natural Language Processing**
Natural Language Processing is the technology used to aid computers to understand the human's natural language. Natural Language Processing, usually shortened as NLP, is a branch of artificial intelligence that deals with the interaction between computers and humans using the natural language. The use of NLP to understand social, political, and economic processes aspects in disaster management has become popular with the increase in the volume of data about human communication, including text, audio, and video [4].

Example applications include automatic extraction of international events from political context [5], public opinion measurement from social media posts [6], sense of place [7], and community happiness [8]. There are a growing number of uses of NLP methods to understand topics of disasters, [9, 10].

c. **Machine Learning in Disaster Management**
AI and machine learning can help public safety officials refine strategies over time, getting smarter about planning and response. AI can be used to analyze event data for patterns, identify current at-risk areas and populations, and model future needs, based on population growth, development, and climate change, among other variables. Government leaders can use these insights to craft policies that reduce the impact of disasters on communities, like planning new buildings in less vulnerable areas, [25].

(2) **Intelligent Systems Based IoT and Cloud Computing in Disaster Management**
IoT refers to a network of physical objects embedded with sensors and software that collect data and communicate with one another.

As it relates to emergency management, IoT can be used to enhance data collection from the physical environment and quickly communicate this data to different city departments, [26].

During a crisis, IoT technology can help by continually updating which evacuation routes are no longer available and what transit options are up and running, for safer, faster mass people movement, [21]. Say there's a fire in a building or a stadium: IoT-powered systems can help direct individuals to all approved exits, while providing updates on which to avoid, [25].

Authors in [11] proposed an approach based on the ant system algorithm and Internet of Things. IoT was used to consider smoke concentration, temperature carbon monoxide concentration. Then, they apply ant colony algorithm for intelligent evacuation. The purpose of intelligent evacuation is achieved.

Furthermore, based on the research foundation of building data model construction, intelligent evacuation application, indoor location, shortest path solution and other issues, an intelligent evacuation system for large public buildings based on mobile terminal is constructed.

The proposed project in [12] is based on the powerful spatial analysis function of GIS, and uses the IoT, sensor network and artificial intelligence algorithm to analyze events in the intelligent space processing system, to support the development of intelligent evacuation systems for large public buildings. Large public building intelligent evacuation system takes mobile terminal as carrier, and install sensors, RFID tags, etc. in the interior space of the building, aiming to provide technical services such as emergency evacuation guidance and escape rescue for the personnel in the disaster.

In [13], the sensor network, which will be installed around 47 volcanoes that the Japanese government has selected for around-the-clock observation, will measure several different variables. In addition to the seismic activity that almost always occurs before an eruption, the sensors will monitor gas emissions, topography changes, and vibrations in the air caused by rocks and ash spewing from the volcano.

The information gathered by the sensors will be transmitted via LoRa [27], gateways to manned monitoring stations located 5–10 km away from the volcanoes. LoRa, also known as LoRaWAN, operates using a chirp spread spectrum radio scheme, sending data through a series of gateways that serve as a bridge between the sensors and network servers.

BRINCO system is the first IoT-enabled beacon that is designed to notify its user about possible earthquake or tsunami in personal-aware mode. The sensor system comprises of accelerometer, signal processing unit and audio alarm units. It works as follows. If it perceives a vibration of the ground, it sends this information to the Brinco Data Center (BDC), a private cloud service. This DC assimilates this information with other seismic networks information to obtain its perception. Finally, if the judgment is good enough, it makes alarming sound and sends push notifications to it users smart phone (Android or iOS) instantly. Further, this information can be shared among the local as well as global community utilizing social network sites, [28].

BRCK It is versatile IoT-enabled device meant to be used in poor infrastructures. This gives it power to connect with low connectivity areas where 2G communication still exists. It is also em-powered with its private cloud service where environment data could easily be transmitted and fetched on. It is capable to work with solar energy, hence very much suitable for disastrous sites where flawless power is a main constraint. The rugged design makes Brck the most suitable product to be deployed in disaster management scenario. Users having smart phone can easily connect with it and share the information to other WiFi-enabled local devices, [29].

a. **Discussion**

   Intelligent systems have some characteristics making them difficult to apply in middle and low SDI countries, where infrastructures are also poor. We present bellow some of these characteristics.

Data Cannot be Effectively Collected

How to realize the integration of disaster data becomes an urgent and necessary key problem.AI related data include meteorological data, urban waterlogging data, socioeconomic data, and other sources, and the amount of data is huge. Furthermore, as the data come from different departments such as water conservancy, meteorology, urban management, operators and Internet, the spatial and temporal scales are not compatible with each other, and the format standards are not unified, which poses a great obstacle to the AI for natural disasters, [14, 15].

Incomplete Information
Decision is a question of timing, and this is particularly prominent in intelligent systems because of the sudden, rapid evolution of disasters. Short time emergency decision face the restriction of personnel, resources, information and other factors, therefore, decision information is discredited and incomplete, [16, 17]. How to deal with the incomplete information constraint is a difficult problem faced by intelligent systems.

Data Unavailability
Intelligent information processing techniques based on AI and machine learning such as big data mining, remote sensing and GIS are promising methods, especially when applied with a combination of conventional forecasting approaches working to update dynamic demand information. However, its application is constrained due to the lack of data availability from governments concerning risk and safety issues during the urgent and limited time after unconventional emergency events have occurred. From this perspective, the access to open source data from governments should be properly unimpeded, [18].

Prediction Problem
In emergency situations there is an inherent demand uncertainty, requiring a large scale of data sources to explore the characteristics of the target prediction case. A great deal of crucial information required for demand predictions is difficult to obtain in the hours immediately after an emergency event. Additionally, in order to save as many lives as possible, analysis of large-scale data requires information processing techniques and methods to be rapid and efficient, making the demand prediction problem based on information processing techniques unique and challenging, [34].

(3) **Smartphone Applications for Disasters Management**
When a disaster happens, the Smartphone is generally used to send information report. If a natural disaster happens, disaster information, including time, location, classification, degree, trend of disaster, etc., need to be collected and sent to the emergency management center through Smartphone. Among information, the geometry location of the disaster is provided by the Smartphone's location based services, [18, 19].

a. **Smart Rescue**
The basic notion of Smart Rescue is to use Smartphone technology to assist in delay phase in the initial crisis times. Smart Rescue technology maps threats and help people in the case of emergency. If many Smartphones are sensing the environment surrounding the people then those phones are used as input sources for getting threat pictures and allow and inform people to take necessary actions to avoid any hazards in the affected area [1].

b. **FEMA**
The FEMA Application (Smartphone app for mobile devices) contains disaster safety tips, interactive lists for storing your emergency kit and emergency

meeting location information, and a map with open shelters and open FEMA Disaster Recovery Centers (DRCs). Bellow some FEMA functionalities [31].

- Receive real-time alerts from the National Weather Service for up to five locations nationwide.
- Share real-time notifications with contacts via text, email and social media.
- Learn emergency safety tips for over 20 types of disasters, including fires, flooding, hurricanes, snowstorms, tornadoes, volcanoes and more.
- Locate open emergency shelters and disaster recovery centers in the area where user can talk to a FEMA representative in person.
- Prepare for disasters with a customizable emergency kit checklist, emergency family plan, and reminders.
- Connect with FEMA to register for disaster assistance online.
- Upload and share disaster photos through Disaster Reporter.
- Toggle between English and Spanish.
- Follow the **FEMA blog** to learn about the work FEMA does across the United States.

c. **First Aid Application (FA)**
FA is developed to give some preliminary instructions for taking care of users in Android Smartphones; basically navigation system uses Google API (maps) for searching an appropriate or suitable way or path to the nearest hospital. In the case of any emergency this function is activated on user’s Smartphone to navigate victims through the shortest path to the hospital [2]. This application gives some useful instructions or precautionary measures about taking initial care of the patients before sending them to the doctors or hospitals.

d. **Fire Ready (FR)**
FSC (Fire Service Commissioner) has launched the fire ready application is the official Victoria government app for Country Fire Authority (CFA), Metropolitan Fire Bridge (MFB) and Department of environment, Land, Water, Planning (DELWP). This fire warnings and information system, notifies users of fire dangers in affected area and sends photographs of bushfire activity. Application is managed by Victoria emergency management on behalf of the fire agencies, supported by the department of Justice and Regulations, [32].

e. **Automatic Crash Notification (ACN)**
Christopher Thompson presented another innovative application that is Automatic Crash Notification system. The aim of this application is to save lives by reducing time required for emergency teams to arrive to victims. ACN sensor network in automobiles is used to detect car accidents, it also communicates with a checking or monitoring station through radio cellular network. Sensor devices provide useful information to detect auto car destruction. Wreck watch server utilize ACN system to detect car accidents that are displayed on Smartphone devices and the user is instantly allowed to access accident information through webpage [20].

f. **MYSHAKE**
It is an APP-based service for the detection of seismic activities. This APP has initially to be installed on users smart phone which whenever perceives a ground vibration through the phones accelerometer, performs a match operation with the vibrational profile of the quake. If matched, the information along with the present GPS coordinate (received from the Smartphone) is sent for analysis to the Berkeley Seismological Laboratory (BSL) for final check. This has opened a way to develop a cost-effective, distributed and crowd sourced quake monitoring system that is obviously a demand of time, [30].

3 Scream to Survive System (S2S)

S2S system combines the use of Smartphones, widely spread even in developing countries, and voice recognition to help victims. Generally, a disaster victim is enable to access to his Smartphone and ask help, with this system, saying "help" will be enough to send automatically alerts to the nearest Emergency Operation Services (EOS).

The essential feature of this system is the ability to analyze victims voices, words, sentences, etc., in order to detect the emergency situation and immediately transmit victims GPS location, identification, etc.

In EOS side, after the first alert, the system save victim GPS coordinates and collect instantly all near users locations (potential victims). It proceeds to alert EOS staff, family contacts and eventually nearest volunteers registered in the system.

Some of the basic objectives of S2S are:

- It automatically detects any disaster by using voice recognition algorithms.
- It responds in the time of critical situations by using real time system, right records are sent at right time. Also, the other stakeholders are informed automatically by S2S and the alerts are communicated through notifications, SMS, email etc.
- It responds to emergency situation with minimal human/manual intervention and interaction.
- It takes into account potential victims, by collecting all near users having S2S system on their smart phones.

S2S system is composed of two parts:

(1) **S2S for victims and citizens (Android or IOS Smartphone)**

This application collects voices, words or sentences, said by the victim, through Smartphone microphone and converts them to text in order to deduce the emergency situation and its type (fire, earthquake, flood, etc.).

After that, the application sends an alert message containing victim information, his last location and risk type to the EOS.

(2) **S2S for EOS**

For EOS, we propose S2S part that allows officers and employees to receive alerts sending by victims and select the appropriate action plan according to emergency type.

They can consult all medical and personnel information from database and send help to the exact location of the victim.

The system collects all near users positions. This information will be very useful for victims relief, in case of earthquake for example.

Furthermore, the system sends victims location to nearest volunteers and family contacts to increase surviving chance. The process is detailed in Fig. 2.

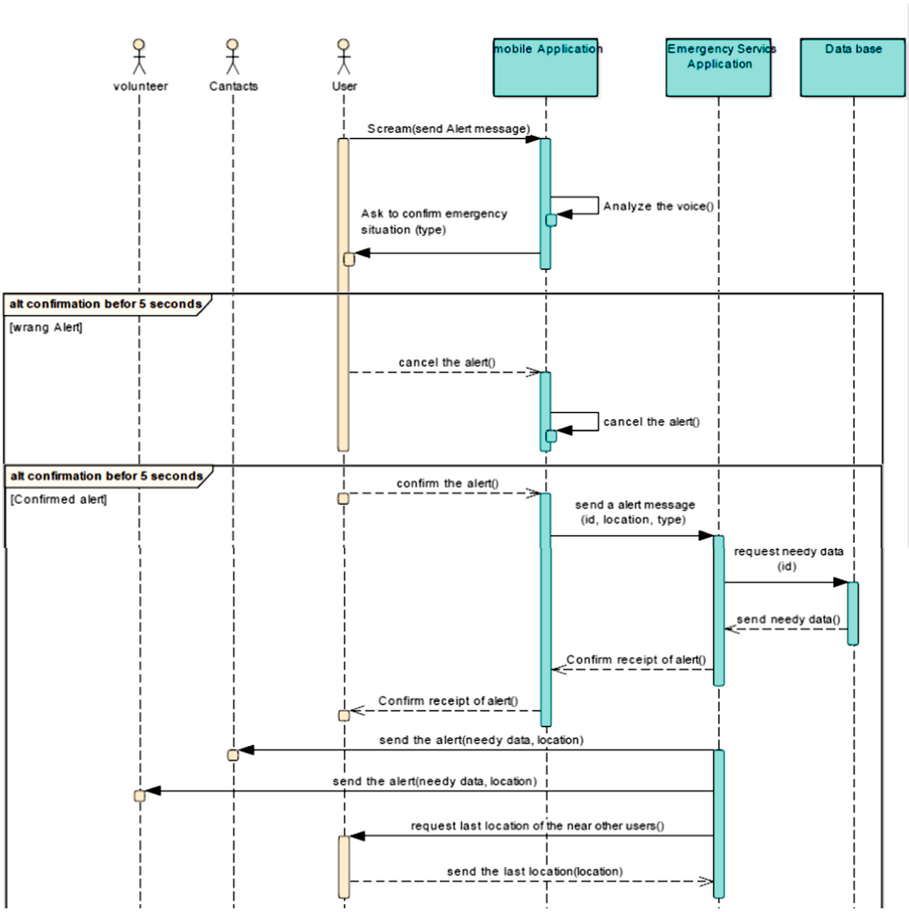


Fig. 2. S2S Sequence diagram between system actors

4 Implementation

In this section, we will describe implementation principals and tools. Then we present some screens of S2S system.

(1) Implementation Tools

a. Flutter

Flutter is Google's mobile app SDK that gives developers an easy way to build and deploy visually attractive, fast mobile apps on both Android and iOS platforms.

Flutter is an app SDK for building high-performance, high-fidelity apps for iOS, Android, and web from a single codebase.[1] Flutter combines a Dart framework with a high-performance engine.

The Flutter Engine is a portable runtime for high-quality mobile applications. It implements Flutter's core libraries, including animation and graphics, file and network I/O, accessibility support, plug-in architecture, and a Dart runtime and tool chain for developing, compiling, and running Flutter applications.

Dart[2] is a client-optimized language for fast apps on any platform, made by Google, it is:

- Optimized for UI: Develop with a programming language specialized around the needs of user interface creation.
- Productive development: Make changes iteratively, use hot reload to see the result instantly in your running app.
- Fast on all platforms: Compile to ARM & x64 machine code for mobile, desktop, and backend. Or compile to JavaScript for the web.

To develop the UI of S2S system, we choose Flutter for many reasons, here some of them:

- Faster code writing: With flutter we can make changes in the code and see them straight away in the app, this is called Hot reload, which usually takes milli-seconds and help teams add features, fix bugs and experiment faster.
- Faster apps: Flutter apps work in a smooth and fast way, without hanging and cutting while scrolling.
- Same app UI on older devices: Your new app will look the same, even on old versions of Android and iOS systems. Flutter runs on Android Jelly Bean and newer, as well as iOS 8 and newer.
- And the most important reason why we choose flutter is **one code for two platforms:** this means that we can code once and get same app for two platforms (Android and iOS), that helps us to spread S2S system in both platforms and target more users.

b. TensorFlow Lite

TensorFlow Lite is a set of tools to help developers run TensorFlow models on mobile, embedded, and IoT devices. It enables on-device machine learning inference with low latency and a small binary size.[3]

S2S system will be used in emergency situation and with that a lot of pressure is put on the device to act accordingly. The biggest problem we are dealing with is weak

[1] Official flutter documentation: https://flutter.dev/docs/resources/technical-overview.

[2] Official dart website: https://dart.dev/.

[3] Official TensorFlow website: https://www.tensorflow.org/lite/guide.

internet connection (maybe loss of internet connection). Which will limit the process of being able to send data back and forth from the server. On the other hand, we offer a lot of benefits that comes with an on-device machine learning such as:

- Privacy: Data will not leave the device.
- Connectivity: Internet connection isn't required
- Power consumption: Network connections are power hungry

(2) **Principles of voice recognition implementation**

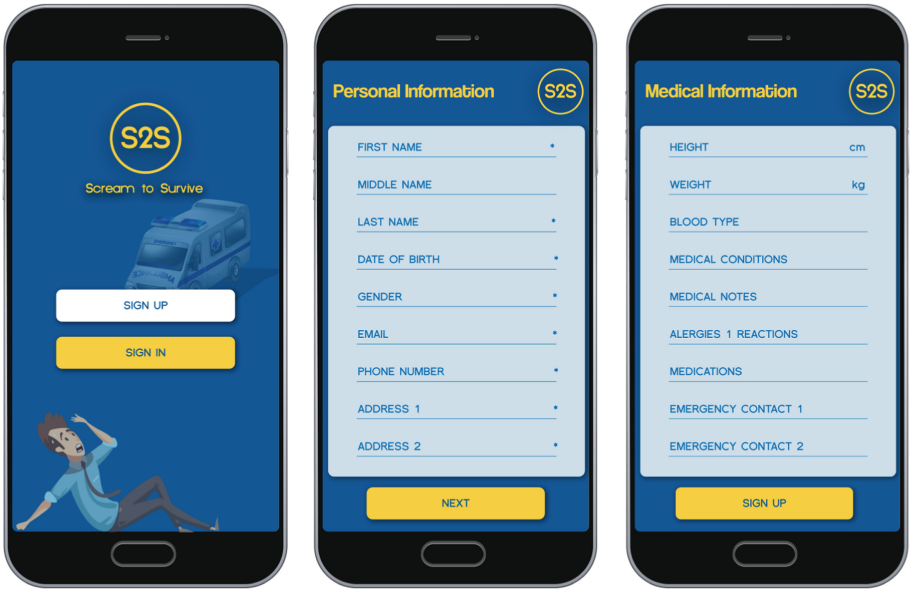
When a catastrophe occurs, the victim is in a state of fear and panic, so he begins to shout and ask for help in order to survive. The first step we do is to build datasets words said during disasters as well as surrounding sounds.

- The first dataset is a sample of a human words during a disaster.
- The second dataset is a sample of surrounding voices when a disaster strike.
- The third is a combination of the first and the second.

The second step is building files with the extension **.tflite** models (created with TensorFlow Lite) from our datasets and integrate them in S2S mobile application where the captured voice will be compared with models.

(3) **Prototyping**

We realize S2S prototypes: for the victim and the EOS.



(a) (b) (c)

Fig. 3. a. Signing screen b. Personal information c. Medical information

- **S2S system for the victim**

Some screens of S2S application for the victim are shown in Fig. 3. User login to the application to update his information. In emergency situation, user access directly. The system collects medical information which will be used to help him in emergency situation. Furthermore, the user enter emergency contacts.

When the application detects an emergency (after voice recognition process and translating to words and/or texts), it will ask user to confirm the sending or cancel it during 5 s then it sends the alert message automatically to the EOS. The message contains user id, type of emergency and last location. The goal of the confirmation is to avoid errors and conflict situation (one can discuss with friends about earthquakes) (Fig. 4).

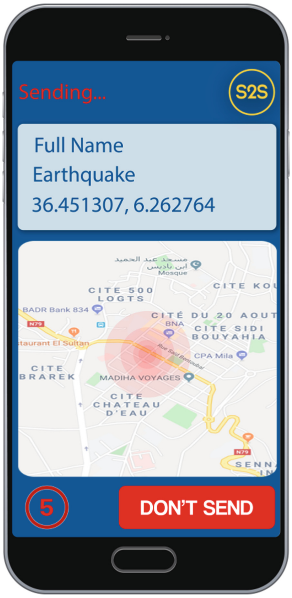


Fig. 4. Voice recognition and sending process

- **S2S system for Emergency Operation Services**

In the side of EOS, when officers receive the alert as notification and a red label will appear in the map, as shown in Fig. 5. Using the received information about victim, S2S EOS gives the possibility to consult all victims personal and medical information. EOS employees will send helps to the exact locations.

Furthermore, we propose messages to emergency contacts and to nearest volunteers, Fig. 6. This is called: Crisis Mode.

5 Performances Evaluation

All systems, presented in this paper, have been grouped together in Table 1 in order to compare and analyze them. We have Intelligence and new technologies based systems and Smartphone based systems.

We can observe that most of presented intelligent systems are successful in countries where infrastructures are adapted, because they are based on new technologies (IoT, permanent Internet connection, cloud, WSN, etc.).

As for communication, it is done through advanced technologies such as WSN, internet, satellite telemetering technology, high-precision air-to-land observation technology.

Fig. 5. S2S EOS: Victims list with the last positions (Red Sparrows) (Color figure online)

Fig. 6. S2S EOS: Crisis Mode Activated: Collecting all surrounding victims coordinates

Table 1. Comparison between Intelligent based Systems, Smartphone based Systems and S2S.

Disaster management solution	Used technologies	Automatic activation	Feasibility low and middle SDI countries	Taking other victims in consideration	Communication	Disaster management levels
Works based on New Technologies						
Mobile fire evacuation system [11]	Iot, Indoor location (Ant Algorithm)	Yes	Medium	No	WiFi, WSN Internet	Recovery
GIS and IoT for evacuation [12]	Iot, Powerful spatial analysis function Of GIS, AI algorithms	Yes	Low	No	WiFi, WSN, Satellite telemetering Internet	Recovery
WSN for active Volcanoes [13]	Sensors, Analysis function of GIS, AI algorithms, Cloud	Yes	Low	Yes	Wifi, Servers Network, WSN, Satellite telemetering, Internet, Lora	Preparedness
BRINCO [28]	Sensors, Big data	Yes	Low	Yes	Accelerometer, Signal Processing, WiFi, WSN, Internet, Smartphones	Preparedness, Response
BRCK [29]	Iot, Smart devices, Cloud, Wifi	No	Good	No	WiFi, WSN, Internet, Smartphones	Response, Recovery
Smartphone applications for disasters management						
Smart rescue [1]	Sensors network, WiFi	No	Medium	Yes	WiFi, WSN, Internet, Smartphones	Preparedness, Response
FEMA [31]	GIS, Cloud	No	Medium	Yes	WiFi, WSN, Internet, Smartphones	Response, Recovery
First Aid Application [2]	GIS,	No	Good	No	WiFi, WSN, Internet, Smartphones	Response,
Fire Ready [32]	GIS, WiFi, Sensor network	Yes	Low	No	WSN, Internet, Smartphones	Mitigation preparedness, Response
Automatic crash notification [20]	Sensor network,	Yes	Medium	No	Internet, Smartphones, Wifi, WSN	Response
S2S: Scream to Survive System						
S2S	GIS, Voice recognition algo	Yes	Good	Yes	Internet, Smartphones	Response, Recovery

In disaster situation they are automatically triggered or activated. and take into consideration several victims at a time. But most of these systems are not feasible in SDI-reduced countries.

For their part, Smartphone-based systems are mostly feasible in these countries, because Smartphone today is widely used. But, most of these systems are not activated automatically and do not take the other users in consideration (only those who have the application installed on their Smartphone).

In addition they do not take into account the rescue level which is very important to save lives after any disaster.

Our system is a combination between smart systems and mobile apps on Smartphone. On the one hand we used simple artificial intelligence algorithms for voice recognition.

On the other hand, communication will be done either by telephonic network or Internet (depending on the situation of these networks) to inform the EOS. Furthermore, our system takes into consideration a maximum of victims by collecting their coordinates as soon as the disaster happens.

Finally, the system takes into consideration the two levels where most lives could be saved: response and recovery.

6 Conclusion

In recent years the disaster impact on human and material losses are considerable, especially in middle and low SDI countries.

There are many systems designed for EOS in case of disasters to help the victims. But these systems are often expensive for middle and low SDI countries. That is why we have proposed in this paper Scream to Survive system (S2S) based on Smartphone, as they are increasingly used, and artificial intelligence technology for voice recognition. With S2S system, it is sufficient for the victim to say words about disasters or for asking help. The system is automatically activated to send notifications (sms, notifications, etc.) to the EOS, to the victims' contacts and to the volunteers pre-registered in S2S system. Furthermore, in the case of disasters like earthquakes, the system proceeds to the collection of close people positions. It will be very useful in the recovery relief.

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