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Short paper

Automatic measurement of departing times in smartphone alerting systems: A pilot study

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Abstract

Aim: Smartphone alerting systems (SAS) alert volunteers in close vicinity of suspected out-of-hospital cardiac arrest. Some systems use sophisticated algorithms to select those who will probably arrive first. Precise estimation of departing times and travel times may help to further improve algorithms. We developed a global positioning system (GPS) based method for automatic measurements of departing times. The aim of this pilot study was to evaluate feasibility and precision of the method.

Methods: Region of Lifesavers alerting app (iOS/ Android, version 3.0, FirstAED ApS, Denmark) was used in this study. 27 experiments were performed with 9 students, who were instructed to stay in their flats during the study days. A geofence was set for each alarm in the alerting system with a radius of 10 m (8 cases), 15 m (10 cases), and 20 m (9 cases) around the GPS position at which the alarm was accepted in the app. The system logged responders as being departed when the smartphone position was registered outside the geofence. The students were instructed to manually start a stopwatch at the time of the alert and to stop the stopwatch once they had entered the street in front of their flat.

Results: The median difference between automatically and manually retrieved times were −16 seconds [interquartile range IQR 50 seconds] (geofence 10 m), 30 seconds [IQR 25 seconds] (15 m), and 20 seconds [IQR 13 seconds] (20 m), respectively. The 20 m geofence was associated with the smallest interquartile range.

Conclusion: Departing times of volunteer responders in SAS can be retrieved automatically using GPS and a geofence.

Keywords: First responder, Smartphone alarming systems, Out-of-hospital cardiac arrest, System saving lives

Introduction

Out-of-hospital cardiac arrest (OHCA) is a time-critical event that requires immediate treatment. The concept of geo-referenced alerting of volunteers in the vicinity of a suspected OHCA via a smartphone app or text message has been established in many countries to shorten the resuscitation-free interval.[1] This concept is part of the recommended measures in the new chapter "Systems saving lives" of the ERC guidelines 2021.[2] Text message systems have the disadvantage that first responders are not being located,[3] or in case of using mobile phone positioning via Global System for Mobile Communication (GSM) they are not very precise.[4] Smartphone alerting systems (SAS) result in shorter response times than text message systems.[5]

As the intention of SAS is to shorten the resuscitation-free interval (and the time to first shock) different systems measure first responder response times and aim to further improve them.

Future improvements can be realised by development of sophisticated algorithms alerting those first responders, who will arrive at the soonest possible time after being dispatched. The time from alert until arriving at the emergency location can be as short as 3–5 minutes in mixed urban–rural areas.[6,7] In the Region of Lifesavers system, which is the largest first responder system in Germany, we experienced that sometimes volunteers are alerted while driving or walking at the street resulting in immediate movement towards the emergency location. On the other hand, volunteers may need two or three minutes to leave their home or working location and to start running or driving. The possibility to monitor the departing times of first responders would give us the chance to match departing times with factors such as for example GPS precision or velocity at the time

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of the alert. If we find factors, which correlate with short departing times, a future algorithm could take this into account.

It is obvious to use GPS to determine the departing time. The position, at which a first responder accepts an alert can be revealed from the smartphone. However, the exact position at which the first responder enters the street or road is not known. Furthermore, GPS coverage in buildings is less precise than on the street and thus the smartphone GPS system may deliver false data.

Aim of this pilot study was to investigate whether the departing times of first responders can be determined automatically using Global Positioning System (GPS). Furthermore, the authors aimed to find optimal geofence settings for automatic determination of departing times.

Methods

Smartphone alerting system

The system "Region of Lifesavers" uses an alerting app (iOS and Android, version 3.0, FirstAED ApS, Denmark), which is connected via a software interface to the local dispatch centre. By using the app, all first responders must agree to the end-user license agreement (EULA) before use. In case of an emergency call with suspected OHCA the mission control computer suggests activation of the system. If the responsible dispatch centre agent confirms, the system is triggered. Volunteers are alerted, who are in close vicinity (5,000 m airline distance) of the emergency site. The alerting app plays a loud sound, and the volunteer chooses whether he or she is available or not. If there is no response, this is regarded as "reject". First responders, who accept an alert are requested to select the means of transport (car, bicycle, running) they use to reach the emergency site. The FirstAED server calculates individual travel times for every first responder with his or her individual transportation type using Google maps and compares this travel time with the estimated time enroute (ETE) of the ambulance. The two first responders with the shortest calculated travel times are directed towards the emergency location if their travel times are shorter as the ETE of the ambulance. The third rescuer is directed to the next publicly available automated external defibrillator (AED) and brings it to the emergency site. The fourth rescuer (with the longest estimated response time) is requested to stand on the road wearing a high-visibility vest and instruct the ambulance personnel to easily find the emergency location.

When a first responder is alerted via the app and receives a task, the app sends position updates using GPS constantly for 20 minutes.

Test setup

27 test alarms were initiated via the backend system between 7 January and 2 February 2023. A group of 9 students served as test persons and downloaded the app. The experiments were performed in the city of Karlsruhe, which is covered by 5G mobile phone network. Test persons were informed that they will be alerted at a randomly determined time of a specific day between 12:00 am and 11:00 pm. They were instructed to stay in their flat during the day of the alert. When the volunteers received a test alarm, they had to trigger the stopwatch app at their smartphone. When leaving the building and entering the nearest public road or street towards the simulated emergency site they were instructed to stop the watch and to note the time from receiving the alert until they were at the street. The students were further instructed to walk towards the simulated emergency site for a minimum of 100 m to ensure exit from the geofence regardless of whether it is set to 10 / 15 / 20 m.

Automatic measurement of departure times using geofence

In the backend system a geofence was set in every case and for every responder around the GPS position of the first responder at the time he or she accepted the alarm. 8 experiments were carried out with the students, in which the system logged the test persons as being departed after the position of their smartphone was outside the 10 m geofence. 10 further experiments were performed with a geofence of 15 m, and 9 test alarms were created with a geofence of 20 m (Fig. 1).

The measured times from all experiments were collected and for each test the manually stopped time intervals were compared to the time intervals which were revealed using the geofence.

Statistical analysis and ethics

For this pilot study small sample sizes were chosen to evaluate feasibility of the methods and to compare the values for manual and automatically retrieved process times. Descriptive statistical analysis was performed using MS Excel.

The work was part of final theses of Karlsruhe Institute of Technology (KIT). The study was reviewed and approved by the relevant examination committees. The alerting system Region of Lifesavers has been approved by the responsible data protection officer. During the study period the system was not active for real cases and no patients were involved.

Results

In all test series, automatically and manually retrieved departure times could be retrieved according to the study protocol. No problems with network, software or connection were detected. The results for the three different geofence set ups are depicted in Table 1..

Using a geofence with a 20 m radius around the position of the first responder during acceptance of the alarm results in the smallest interquartile range between automatically and manually retrieved data.

Discussion

Modern algorithms in SAS aim to achieve smallest possible response times of volunteer responders and earliest possible time to first rhythm/ shock. Some systems send an alert to up to 30 volunteers.[6] This strategy seems reasonable as a high number of volunteers being activated may increase the chance to achieve a very short response time of the first arriving responder. However, alerting many responders (of whom only three or four are needed to perform BLS) may result in reduced motivation to accept alerts. Some systems are deactivated during nighttime.[6,8,9] The Region of Lifesavers system/ FirstAED alerting software uses an algorithm which identifies volunteers, who are close to the emergency location, but prior to distributing tasks to first responders the travel time is calculated, considering the mode of transportation. Those two volunteers believed to be the fastest to arrive will be sent directly to the patient. This is important as fetching an AED result in delays of several minutes.[10] To our knowledge only one system considers departing times

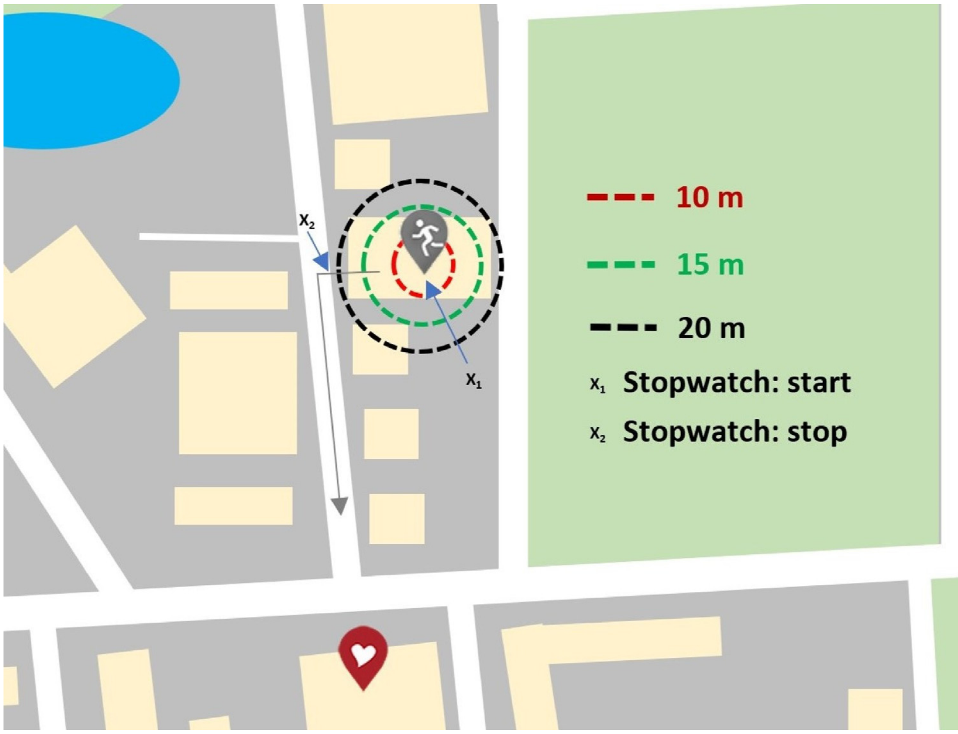

Fig. 1 – Measurement of departing times. When an alarm is accepted in the alerting app, the GPS position is saved in the smartphone and a geofence is set with 10 (15, 20) meters around the position (schematic). The time is measured until the position of the smartphone is outside the geofence. Furthermore, the students stopped the time from the alert (X_1) until they entered the closest public street (X_2) to run towards the simulated emergency location (red heart symbol).

Table 1 – Automatically retrieved and manually stopped departure times. All times are given in minutes and seconds (mm:ss), Q1 = first quartile, Q3 = third quartile.

	Geofence 10 m		Geofence 15 m		Geofence 20 m	
	automatic	manual	automatic	manual	automatic	manual
Departure times (median, Q1;Q3)	00:43 (00:30; 01:20)	01:00 (00:44; 01:22)	01:27 (01:11; 01:41)	01:06 (00:56; 01:12)	01:07 (01:06; 01:37)	01:00 (00:52; 01:19)
Time difference: automatic – manual (median; Q1;Q3)	−00:16 (-00:23; 00:27)		00:30 (00:14; 00:39)		00:20 (00:14; 00:27)	
Number of experiments (Number of test persons)	8 (6)		10 (8)		9 (7)	

in the alerting algorithm, the respective system calculates a fixed time interval of 1 minute.[11] This study evaluates how precise automatic measurement of departing times can be if a GPS based geofence of 10, 15, or 20 m is used. For the 20 m radius, the median difference is 20 seconds, and the interquartile range is only 13 seconds. A 10 second radius results in slightly less difference (median), but a higher interquartile range of 50 seconds. This can be explained by false logging of departure times due to a lack of GPS precision in buildings. When accepting a test alert, the students accepted the alert and switched to the stopwatch app on their smartphone. This is associated with a short delay, which is a confounder. However, some tests prior to the study revealed a delay of about five seconds, which was almost constant. The results of this pilot study should be validated with larger sample size. Future research should find those factors, which are associated with short departing times. This could lead to an algorithm, which considers the anticipated activation to on-scene time (departing time plus travel time).

Conclusions

Automatical logging using GPS geofence technology enables us to measure departing times in SAS aiming to dispatch first responders even more efficient in the future.

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CRediT authorship contribution statement

Julian Ganter: Conceptualization, Writing – original draft. **Alexander Ruf:** Methodology, Software, Formal analysis. **Julian Oppermann:** Methodology, Software, Formal analysis. **Joschka Feilhauer:** Methodology, Software, Formal analysis. **Thomas Brucklacher:** Conceptualization, Software, Validation. **Hans-Jörg Busch:** Resources, Supervision, Writing – review & editing. **Michael Patrick Müller:** Conceptualization, Writing – original draft.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: MPM is chair of Region of Lifesavers (non-profit organisation), received speaker honoraria from Stryker, and holds shares (SmartResQ ApS, Denmark). JG is member of the board of Region of Lifesavers (non-profit organisation). HJB is member of the executive committee of the German Resuscitation Council and vice chair of Region of Lifesavers (non-profit organisation). TB received honoraria from FirstAED ApS, Denmark, for technical support regarding FirstAED alerting software. AR, JO, and JF have no conflicts of interest.

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