Demo Abstract: *Alzimio*: A mobile App with Geofencing, Activity-recognition and Safety Features for Dementia Patients

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ABSTRACT— **Dementia, Autism, and Alzheimer's disorders affect millions of people worldwide. Suffering from forgetfulness, affected patients tend to wander off and potentially get into dangerous situations. This work develops the *Alzimio* mobile app, to provide safety functions to these patients; including safe-zone geofencing, activity-based alarms, take-me-home, navigate to nearest friend, and check-on-me.**

Six main design goals guided the design of Alzimio, including periodic safety checks, refined user control, flexibility and efficiency of alarms, and optimized operation, among others. Providing reliable continuous sensing and operation without drastically affecting battery lifetime provided a challenge. Such challenge is not unique to *Alzimio*, but is general to most IoT healthcare devices. Novel activity-recognition and geofencing algorithms are designed and optimized to meet the goals and overcome the challenge. The app was evaluated using extensive scenarios of usage for several months. *Alzimio* is able to achieve over 95% accuracy in less than 30 sec in most scenarios. The optimal threshold was found to be 65, to achieve best accuracy and delay. The phone was able to last throughout the day in our tests, which is very promising.

Keywords—mobile health; geofencing; sensing; activity-recognition; Autism; Alzheimer's; Dementia; Mobile App.

I. INTRODUCTION

Alzheimer's and Autism affect millions of lives worldwide, particularly children and elderly. Many of those affected suffer from dementia (forgetfulness). Getting help automatically in emergencies is critical for the patients and their families. In 2017, 63.5% of U.S. population (over 220M users) had smartphones [1], this presents an opportunity and a means to provide help to those suffering.

Type of Disease	Numbers	People who forget
Alzheimer's	5M in USA, 1/60[3]	~60%
Autism	1.1M,1/68 Children[2]	~50%

This research focuses on the design and implementation of features in the *Alzimio* app to allow for periodic safety checks, refined user control of geofence setup, navigation to safety, efficient timed alarms, and optimized activity recognition.

II. DESIGN GOALS AND APPROACH

Alzimio's main goals include enhancing safety for the users and peace of mind to their loved ones and care givers. This is achieved by targeting the following goals:

1- Safe-zone Geofencing: Circular geofences (supported by Android API) and non-circular geofences using polygons, not supported by Android API, can be created. Detecting region-crossing uses the *ray-casting* method. This works by drawing a line starting outside the fence, crossing the user location, then counting the line intersections with the fence. If the number is even then the user is outside the fence, otherwise inside the fence.

2- Activity-based Alarms: Using the activity-recognition Andoid API, and novel threshold-based algorithms, accurate recognition can be performed efficiently. Alarms can be created when a user performs what is a pre-set "unsafe" activity (i.e., one that is considered to be a potentially dangerous activity) such as on-bike, in car, or running.

3- Navigation to Safety: The *take-me-home* feature is done by saving the user's home address during setup, then using it on-demand with the Google maps API to get directions. The *take me to the closest friend* feature is more complicated, and requires getting navigation to each friend, calculating expected times of arrival (*ETA*), ranking the friends, then using the nearest friend's address in the API.

4- Periodic Safety Check: The *check-on-me* feature has a timer running in the background and firing every preset interval. However, if the user fails to respond after several checks, a message is sent to notify the emergency contact person/persons of choice.

5- Optimized *Alzimio* Algorithms: Using collected data of activity-recognition through real world tests, we identify a utility function to reduce delay, and increase accuracy and confidence. The data-driven optimal (peak) value is then obtained.

6- Flexibility and Efficiency of Alarms: By allowing the user to restrict the time that the alarm is running, flexibility and efficiency are improved. This is achieved by having *start* and *stop* timers. When the *start* timer is triggered, the alarm check (sensing) is activated and the next *stop* timer is set. When the *stop* timer is triggered, the sensing stops, and the battery is saved. A daily repeat timer is provided too.

III. SOFTWARE ARCHITECTURE OVERVIEW

Essential building blocks for Alzimio's design are shown in Fig. 1. The sensed data flows from the bottom to the top of the diagram, with the user control shown using dotted lines.

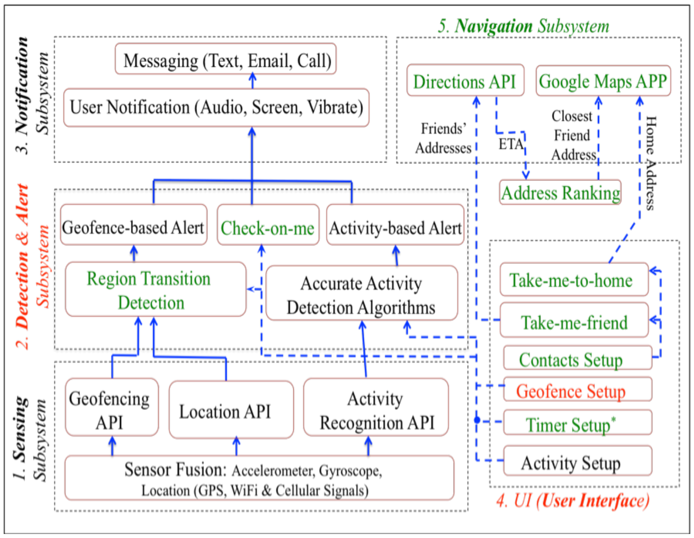

Fig. 1. The Software Architecture Block Diagram for ***Alzimio***

The above block diagram shows the flow of information. It starts with sensors that collect the data along with the User Interface (i.e., from the setup). Next, the APIs processes the data, and trigger the alarms as needed. In cases when alarms are not disarmed within the allotted time the notification subsystem will be triggered causing either messaging via texts or emails. The app also triggers the Google Maps app with address of the patient's home or closest friend. For brevity, following we shall discuss briefly only a few of these features; namely, navigation to safety (i.e., to home or to friend), geofencing, and activity recognition performance optimization.

Navigation to Safety: An example of the process of determining the nearest friend to navigate the user to is shown in Fig 2. There are two types of distances the shortest straight line ("as the crow flies") and the distance using navigation distance. As shown the solid lines yield that '2' is closer, however the dotted navigation lines, shows that '1' is closer.

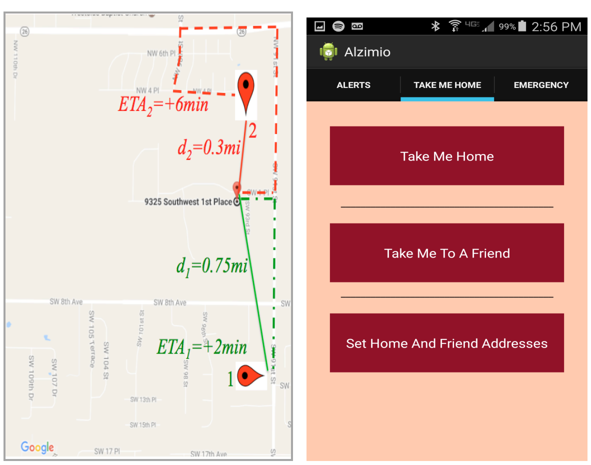

Fig. 2. Distance and ETA comparison (left) and UI (right)

Safe-zone Geofencing: Fig 3. shows the geofencing UI. Android APIs only support circular geofences. We provide extensions to support general polygons and use *ray-casting* algorithms to check safe-zone crossing periodically using the location API.

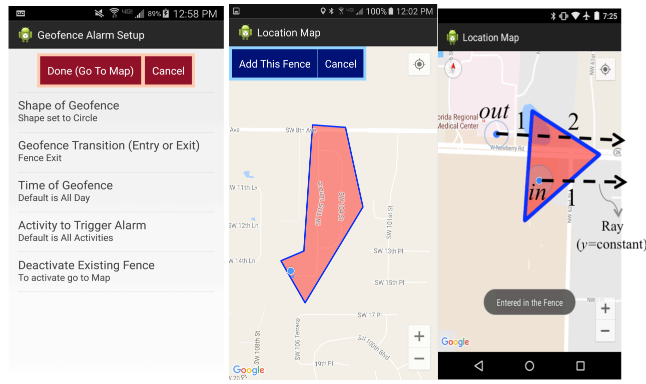

Fig. 3. Geofencing UI, polygon geofencing and ray casting.

Activity-recognition Optimization: There is a trade-off between delay and accuracy in the activity-recognition sensing. Lower delay leads to inaccurate results and visa versa. To obtain optimal performance, we devised a utility function inversely proportional to delay and directly proportional to accriacy to identify the best confidence threshold for activity data filtering.

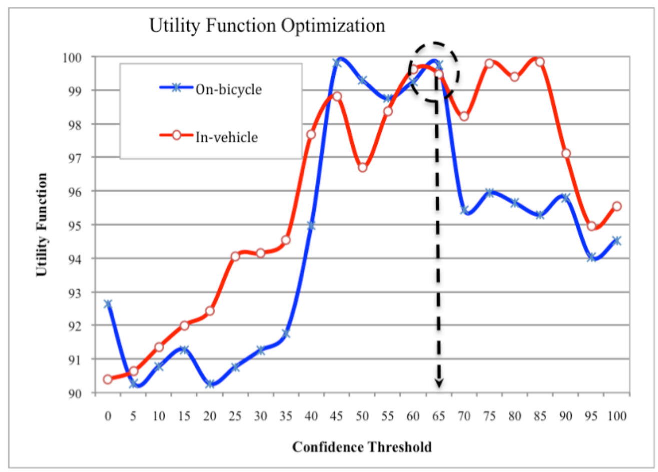

Fig. 4. Optimal threshold (65) to achieve delay less than 30sec and accuracy above 95% in activity recognition.

As in Fig 4, the sweet spot was around 65 percent threshold which got 30 seconds of delay and 95% confidence.

IV. Conclusion

This work presents the first mobile app combining features of flexible safe-zone geofencing, optimized activity-recognition, and navigation to safety targeting users with dementia (including Alzheimer's and autism). This presents the results of over three years of work on this project[4], with extensive field testing and data analysis and refinement. We plan to demo this mobile health app on smartphone and tablet.

References

[1] staistica.com, Number of Smartphone Users in USA, 2017.

[2] "Dementia Fact sheet", World Health Organization, March 2015.

[3] "Alzheimer's Disease", CDC Center, 25 Jan. 2017.

[4] J. Helmy, A. Helmy, "The *Alzimio* App for Dementia, Autism and Alzheimer's: Using Novel Activity Recognition Algorithms and Geofencing", *IEEE SmartComp - SmartSys*, May 2016.