Project Proposal: ubiqui.care

Problem Space

We aim to improve the health, safety and life for elderly people. Aging comes with a lot of disadvantages and we try to reduce the risk associated with falls and declining health. Older adults tend to also have problems interacting with touch-based technology and small displays and therefore can't take advantage of various improvements.

Our target audience consists of elderly people, aged 65 years or older. The people with the highest impact and risk from falls are generally living independently and may suffer from mobility restricting illnesses.

"Every second of every day, an older adult [...] suffers a fall in the U.S." - CDC.gov [1] and after an incident a lot of time can go by till a caregiver notices. But accidents aren't the only health problems: With our personal monitoring we can detect many more upcoming complications before they manifest. When it comes to healthcare, noticing it faster does improve the outcome a lot. Last but not least, elderly people might lack the knowledge to correctly interact with modern technology. By providing an interface via Intelligent Virtual Assistants (IVAs) we try to mitigate this.

There are already a lot of products in this space, like the apple watch or the galaxy watch that we want to utilize. These watches already can already detect falls or car crashes and do this to a high degree of confidence. Their drawback is the lack of integration we aim to provide.
The main obstacle in a path of technological integration seems to be the physical barrier to use the devices. Surface computing devices do make the interactions easier [2] but still pose a barrier. A recent study concluded a 3x increase in input speed and a 20% lower error rate for conversational inputs [3]. When older people do have access to smart speakers they tend to use them slightly more than younger people [4]. So there's definitely potential for driving interactions through this.

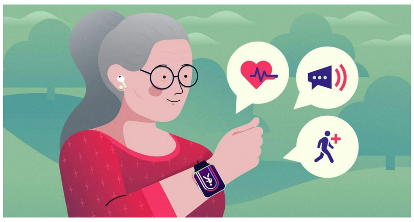
Intervention

We plan to address the problem with a combination of devices, wearable sensors, voice assistant and potentially environmental sensors. The proposed solution supports elderly people's health and daily-life by tracking their nutrition and activity, reminding them to take medication and get to an appointment, informing their caretakers of needed treatment, and assisting in both daily and emergency situations intuitively. We think that this technology would help senior citizens and their caretakers because it provides medical assistance and information to these groups that is otherwise difficult to obtain.

There has been previous work on augmenting the home environment to better support health, aiming to improve elderly health through home monitoring and providing health treatment by sending messages for help [5]. We also wish to monitor and message for help in our solution, in this previous work though it has the user press buttons on their mobile device to send the message or send it automatically. We also use automatic messaging but aim to do user initiated messages through voice assistance in the case they are unable to use their hands due to injury and ease of communication through voice. Other wearable technology aimed at the elderly using voice assistance aim to improve activity by being a voiced motivator to increase activity [6].

We envision our solution to work quietly in the user's everyday life until action is required. An example would be monitoring the users movement around the house, if there is something out of the ordinary such as moving towards the front door at midnight a voice assistant would ask if there is something wrong to attempt to help and contact a caretaker or emergency services of the current situation depending on the severity.

We plan to demonstrate the benefits of our intervention through live demonstrations simulating the problems we solve with our solution: we will set-up the whole system by setting up the voice assistant in the room and attaching the smartwatch to someone's arm. We will then connect all devices to the same network to let them communicate with the server-side. Throughout the life demo, we will first measure and report health values, such as heart rate and blood oxygen concentration. The average values can be requested using a voice-based interaction. We will then simulate a fall event to showcase the automatic detection. The person who fell down will then communicate using the voice assistant to inform about his/her state and to send a message to a relative to step by and check him/her. The fall event as well as the health values measured right before and after the event will be visible for the doctor in the automatically generated report.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Feature List

1) Falling detection: check if the elderly people suffer from a fall using a smartwatch.

Why: Seniors are easily vulnerable to many types of events where they can not get out by themselves such as falling. So in the case that those events occur, they need immediate assistance.

Example scenario: you are a senior and you try to climb down the stairs of your house. Half way down the stairs, you slip your step and fall down to the ground, making a loud falling noise. The smartwatch will detect this. Our system will ask you if you need any help then contact and request assistance from your caretaker as needed. If you happen to be unconscious and cannot respond to the voice assistance prompt within a certain timeframe, it then will contact your caretaker so that your caretaker can assert the situation and determine what to do.

2) Reminders: the user can set up a reminder for a specific task by a certain time and check it off by announcing to the voice assistant when the user is doing that task.

Why: Elder people can have short term memory and can forget to do certain important tasks such as locking the door at night or taking required medication during the day.

Example scenario: you are a senior and your doctor requires you to take a pill before bed everyday. Your bedtime is 9:30 p.m. and you usually take the pill at 9 p.m.. When you take the pill, you will announce it to check off with the voice assistant and the voice assistant will keep track of it. By the next day at 9 p.m., if you forget to take the pill and the voice assistant has not heard your daily announcement by that time, it will remind you to do so.

3) Well-being monitoring: monitoring the senior health-related data such as heart-rates, blood pressure, body temperature, etc. using the smartwatch.

Why: Health is an important aspect of everyone's life, and for older people this is even more important as their immune system worsens as they age, which means that they are even more vulnerable to illness. So it is essential that they are able to monitor their health in order to make sure that their health is functional. Additionally, this data can also be used by their doctors or caretakers to evaluate their treatment of whether it is effective.

Example scenario: you are a senior and one day your blood pressure is much higher than usual. Our system will detect this via sensors from the smartwatch and recommend you to see the doctor. The doctor will give you some medication to use, and our system will keep track of your blood pressure history so that when you visit the doctor again, they can use this data to assess if the medication is working and decide on what to do next.

Use Cases:

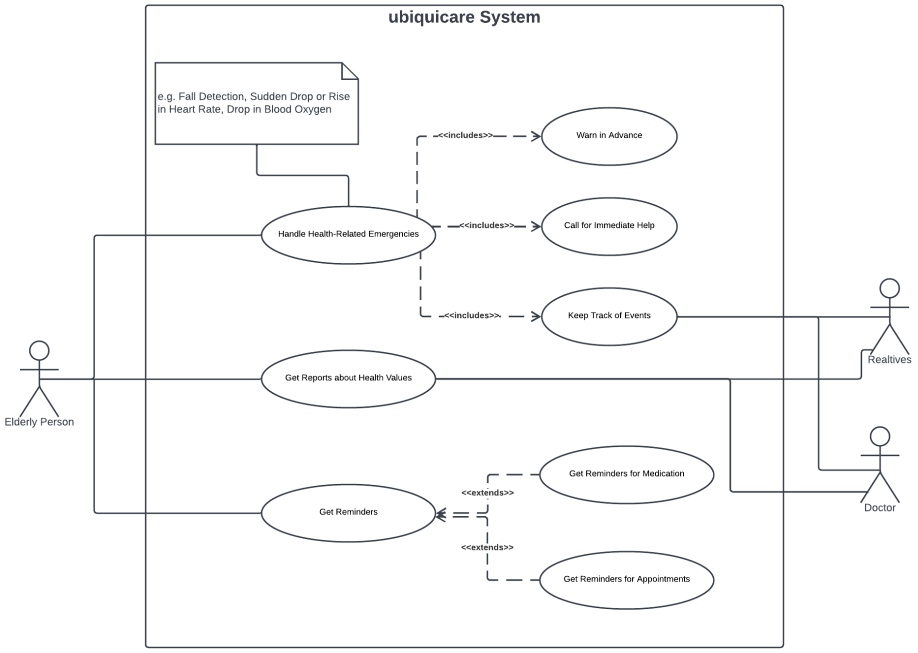

Fig. 1: Use Case Diagram

Devices

The main device we use for sensing data is the smartwatch, in this case the Galaxy Watch. It can sense changes in many health values, such as heart rate, blood oxygen as well as other health related metrics as well as sounds in the environment for fall detection and more.

Another device we use is a voice assistant, particularly Amazon Echo Dot running Alexa, which can help set reminders or provide assistance with day to day tasks as well as help communicate to the person in a natural way or in situations where smartwatch control is difficult or impossible.

Integrating a Raspberry Pi as the central hub and server of our architecture, we can connect the two other devices, send and combine the data and store condense summaries in the database. Optionally, the application on the Raspberry Pi can be further extended in the future with features to sense the environment around the house and communicate with external services.

As the Raspberry Pi and Amazon Echo Dot need power supply, they should be located in the room(s) the user is usually in and to allow communication between them, each of them need a proper WiFi connection.

Architecture

For the setup of the system (see Fig. 2), we will use a smartwatch, a voice assistant and a server deployed on a Raspberry Pi. The smartwatch provides a health tracking application, which monitors the user's health values, such as heart rate and blood oxygen saturation, and can detect abnormal situations, such as fall detection or sudden drops in heart rate or oxygen saturation. This data is exchanged with a server situated in the user's home, which performs analytics and reporting operations on the measurements and reported events and stores them to a database. The user can access this data later on or forward it to the doctor.

Furthermore, the application also supports reminders, so the smartwatch application includes a component for this. It informs the user to take their medication and do not miss appointments. The schedule is stored in a database, which is retrieved through an application on the server-side. To facilitate user interaction, the application supports voice-based interaction. The voice assistant is running on an Amazon Echo Dot and allows the user to set new reminders, access health values and select options in case of an emergency. To interact with the data stored on the server-side, the voice assistant uses the voice assistant bridge which exposes the corresponding endpoints. For the communication, we use REST APIs at the endpoints between the two clients (smartwatch and voice assistant) and the server. The database is PostgreSQL.

The Amazon Echo Dot uses the Alexa Voice Service (AVS) to process voice commands and interact with users. AVS is a cloud-based service provided by Amazon that allows developers to integrate Alexa's voice capabilities into their own products or services. Based on the user's request, AVS identifies the corresponding Alexa Skill or endpoint that can fulfill the command. Skills are essentially voice-driven capabilities that enhance the functionality of

Alexa. The endpoint associated with an Alexa Skill is implemented using an AWS Lambda function. AWS Lambda is a serverless computing service that allows developers to run code in response to events without the need to provision or manage servers.

To secure personal data, the whole setup is locally and raw health data is not stored in a cloud solution. Only on request, health reports can be exported and sent to external parties, such as a doctor. To protect user information, sensitive user data is encrypted before transmitting it between the smartwatch and the server.

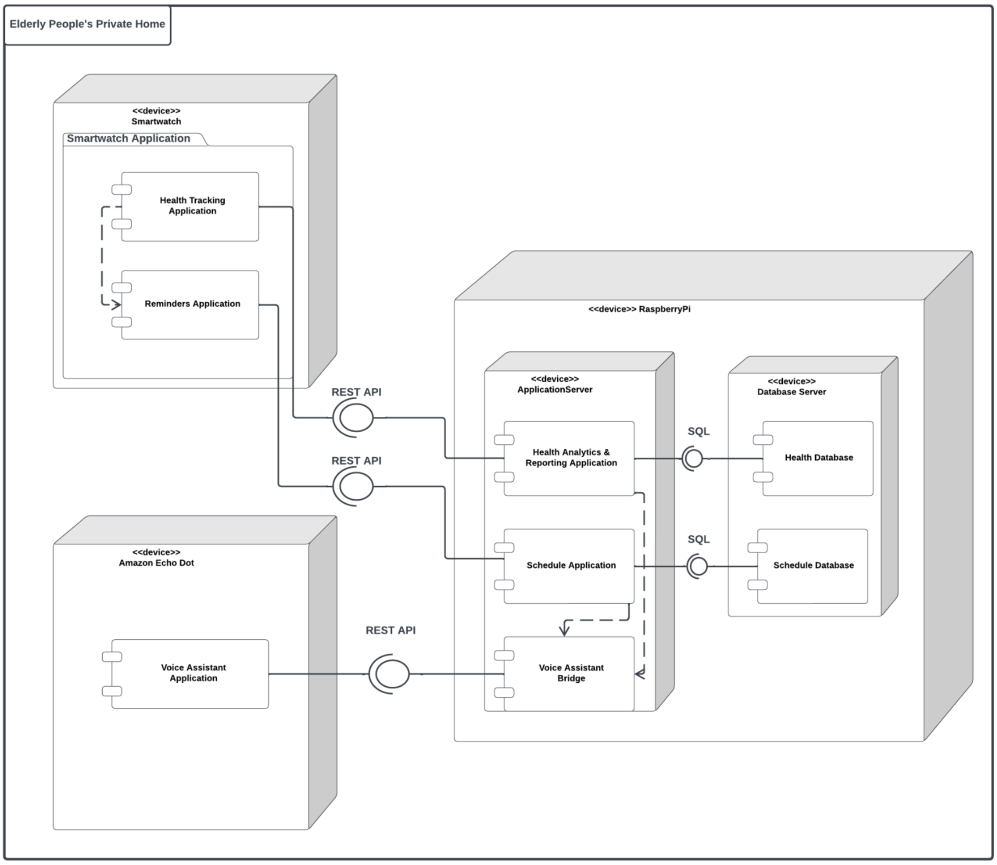

Fig. 2: Deployment Architecture for System Setup using Smartwatch, Voice Assistant and Server on Raspberry Pi

To understand the interactions within the system, Fig. 3 presents a sample sequence of interactions with the system. The smartwatch constantly monitors the health values of the user and detects an abnormality, such as detecting a fall, and forwards this event. The user then has to react to the event either on the smartwatch directly or using a voice-controlled assistant to inform the system what has happened and what action to take, such as contacting someone or calling for immediate help. In case the user is not responding at all, the system assumes the user is in an emergency and selects the pre-configured action for such cases. In any way, the event is reported so that relatives and the doctor, who are allowed to access the data, are aware that it has happened.

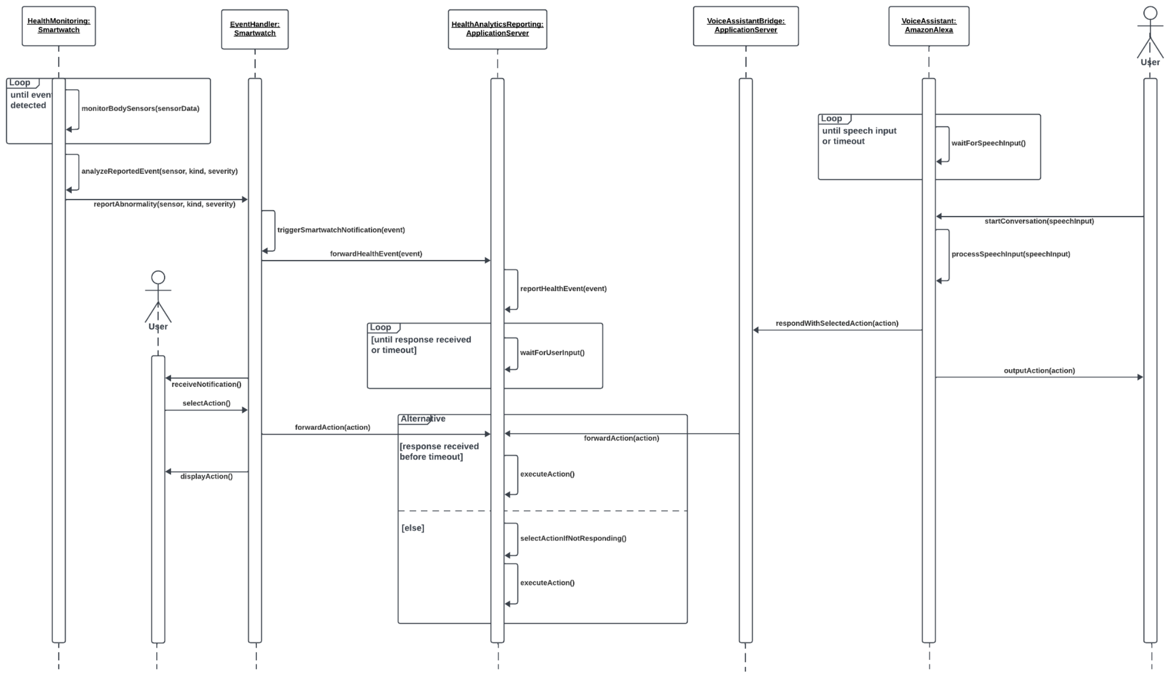

Fig. 3: Sequence Diagram for Use Case Abnormality Detection and Handling

Timeline

Week	Features
1	- Health value tracking on smartwatch (heart rate, blood oxygen and fall detection), displayed on smartwatch and send to health monitoring system - Smartwatch to server communication, including REST API endpoints on server-side and continuously listen to events from server - Notify and display information on smartwatch in case of events (e.g. sudden change of health values)
2	- Voice assistant integration through AVS & Lambda - Voice assistant bridge providing endpoints to call server - Voice assistant skills for responding to health events and requesting health values within specified time frame
3	- Schedule and reminders system (for medication and appointments), managed on the server - Voice assistant skills for setting, checking off and deleting reminders as well as requesting overview of appointments for the day - Reminders sent to smartwatch to notify user
4	- Reports (health value summaries) and dashboard creation - Optional: further activity tracking on the watch (steps, workouts) - Testing

References

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