Emsuch

Creating a system for checking the safety of family during emergencies

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Abstract: This report presents a prototype system that allows an user to check the users house after an earthquake, to see if anyone is hurt or if there any damages to the property. Then goes through if this system could be adopted by the Japanese population. The planned system is a camera, which by using a service from the Japan Meteorological Agency knows when there is an earthquake and then send information in terms of video, pictures or sound to the user's phone or laptop. Would altering the appearance of the camera change people's opinions or are they more concerned about privacy. The goal of this study is therefore to create a prototype of this system and then conduct a survey to see how the Japanese think during a major earthquake. This to be able to adapt the final system into something that fits their needs and is useful. The result will be a presentation of the prototype as well as common answers from interviews about the usability and adaptability of the prototype.

Keywords: video streaming, RaspberryPi, system prototyping, Japanese Emergency procedures, Human-computer analysis.

1. Introduction

In Japan there are many earthquakes throughout the year, thankfully the Japan Meteorological Agency[13](JMA) has a warning system that alerts the inhabitants that a big earthquake is coming. During the big earthquake in Tohoku area, March 2011, several network lines were destroyed as well as the power going out at the main Internet Service Provider(ISP) in the area. Even though the network in the Sendai area was heavily affected, the network in other areas of Japan was still fine.[2] The telephone lines were over flooded by callers making it impossible to get through the first hours/days after the earthquake. So mobile applications such as Line and other chat-like services became popular in Japan. In Japan, many live together with older relatives, be it grandparents or parents, and usually, these older relatives are rather reluctant to new technology. Therefore, they might not have the option to communicate through online messaging applications. So how can those people be reached at home in the event of phones not working? This is what this report tries to answer. The suggested system is consists of an IP camera and mobile application that allows it's user to see the home through a live video stream. The system has been named Emsuch from an abbreviation of Emergency Survival Checker.

Similar systems are being developed but the have yet to hit the public interest. For example, a smart home which has their own server in each house that can connect to neighbouring houses servers to create an ad-hoc network[7]. This to enable the houses servers to send information about the location of possible victims and the house to rescue organisations walking through the area.

2. Problem

When designing this system there were many problems to consider, these problems are presented in this chapter. The main questions this report want to answer are:

- Is the system useful in such emergencies?
- Is it something the older generation can consider using as well?

2.1 Limitations

One thing that must be considered is that the camera have to work during power outs and therefore being able to operate without external electricity and in darkness. As in the recent earthquake of Kumamoto hundred of thousands were without electricity[1] and many of the old buildings collapsed in the area.

If the house collapses during the earthquake the camera might be caught between the roof and the floor or smashed by a wall. So it might break easily, therefore making sure that it can withstand the pressure and stress of such load careful thought has to go into designing the casing. Furthermore, if the house has collapsed the chance of getting a good visual is probably slim.

A final and crucial limitation is that even if there is power, there might not be any infrastructure still working for communicating over. But this study will assume that the infrastructures are up and running. In following studies this will be addressed.

2.2 Implementation

There is also the problem of ethics and aesthetics. As this camera is to be placed in people's home it could clearly be a concern of privacy for the residents. If other people can access this camera's video feed there won't be many people that will consider to use it. Just having a camera watching wherever you go in your house can make people uncomfortable even though it isn't turned on. The other factor to consider is that the camera would need to be placed in a place where it sees most of the apartment or house without obstructed view. Meaning that the camera will most likely be visible to the people living in there. Is it more desirable to make the camera as invisible as possible or design the appearance so that it looks stylish and neat?

Designing the other part of the system, namely the mobile application , should also be given great thought. As it is desirable that even elderly people can and want to use this system for. What traits are needed, how can the interface adapt to older generations needs?

Another implementation problem is for example, from what magnitude of earthquake does Japanese people usually start to worry about family members. As it is undesirable to activate the camera unless necessary, knowing when to turn on is essential. There is also many factors to consider when talking about the severity of an earthquake, for example, distance from the epicentre, depth and what kind of earthquake it was.

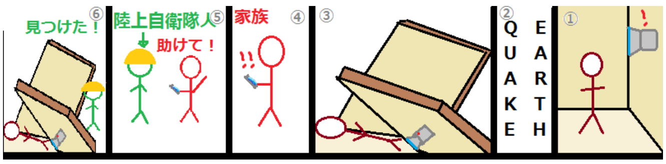
3. Solution suggestion

To find out the answers to these questions a prototype was created to be tested and gather opinions about. To gather opinions a questionnaire in Japanese was created, then it was sent out as a Google Form to members of the lab. Also asking if the participants could send the survey to their older relatives. As elderly people might not be able to take part in an online survey, a more interview kind of data collection was also be used. This includes going to nurseries and asking people on the street.

Current ideas for solving preventing the camera to be crushed involves building a steel skeleton around it which could divert most of the pressure applied from above away from the delicate camera.

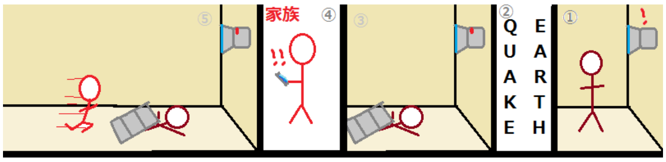
In the event of a power-loss, the camera must keep working as every piece of information might lead to a saved life. So to ensure this a power-bank might be able to switch from current coming from a wall outlet to an internal battery. As the power losses after the Kumamoto earthquakes only lasted between ten minutes up to three hours[12], it could sufficient if the battery could last about six hours before needing recharging.

These scenarios are made up where the desired system could be of use. Later interviews will show if there is any real scenario where this system could be used.



Scenario 1

In scenario 1, the camera is placed on the wall inside the home. There it is always on and looking for movement. First, the camera detects movement in the room and takes a photo. Then shortly after there is a big earthquake which makes the walls of the house fall, trapping a person under the rubble. A family member receives a warning from the camera that there was someone quite recently in the room before the earthquake. The family members try to contact the person in the room by telephone but have no luck. So the family member check the video stream to see if the trapped person is still in the room. But as the camera is facing the floor so the family member can't see what's going on. But if the trapped person is alive and screaming/ asking for help the family member can conclude that someone is trapped under the rubble. So the family member can call to a rescue team and give them the location of the trapped person so the rescue team can find them quickly.



Scenario 2

In scenario 2, the start is the same as in scenario 1, but the earthquake is not as severe. So the building is still standing but the person in the room is trapped under a fallen bookshelf or cabinet. The person can't get out and have no means to call for help except screaming. A family member receives a warning from the system that someone was in the building during the earthquake. The family member tries to call the trapped person but can't reach him/her. Watching the video stream the family member can see clearly that there is a person in the house is in need of help and rushes there to help or call for help.

4. Creation method

Using a mini computer called Raspberry pi[5] as a base for the camera made it easy implementing the different features needed for the prototype. This device was chosen as it is cheap and has high adaptability from being able to add different modules and electronic components quite easily.

Illustration 1: Raspberry Pi V2 [5]

Even though there are many cheap IP cameras available for purchase they are not adaptable and often comes with a finished user interface.

The creation of software was divided into small modules that could be connected to each other in the end. The different modules where, JMA connection, Motion detection, Sound recording, Electricity handler, socket connection and camera functionality.

The current camera casing was made from wood as it easy to manipulate into a desirable form. As there might be a need to add extra modules or remove old, the casing can be screwed apart to alter the content and then screwed together.

Some of the questions asked in the survey were:

- Around what seismic level(Japanese scale) do you start to worry about family members after an earthquake?
- How do you contact your family members after an earthquake?
- Could you consider having a camera like this prototype in your home?
- If you would have a camera would you rather want it fashionable or invisible?
- Is there any privacy issues that might be a problem for you?
- Looking at how this prototype of the system looks today could you imagine yourself using it?
- Could you consider to have necessary data sent to the Self-defense force or Fire and Disaster Management Agency?

Because trends might differ within different age and this study focus on reaching older generations. The participants age, current living status and what phone the participants are using was also recorded.

As there might not be enough answers from a few interviews a questionnaire was created to reach as many people as possible. This was created on Google Drive[6] and was distributed through mail, chat boards and social media. As I only wanted people living in Japan to answer the surveys questions was only presented in Japanese.

5. Emsuch

The suggested system is consists of a camera and mobile application that allows it's user to see the home through a live video stream.

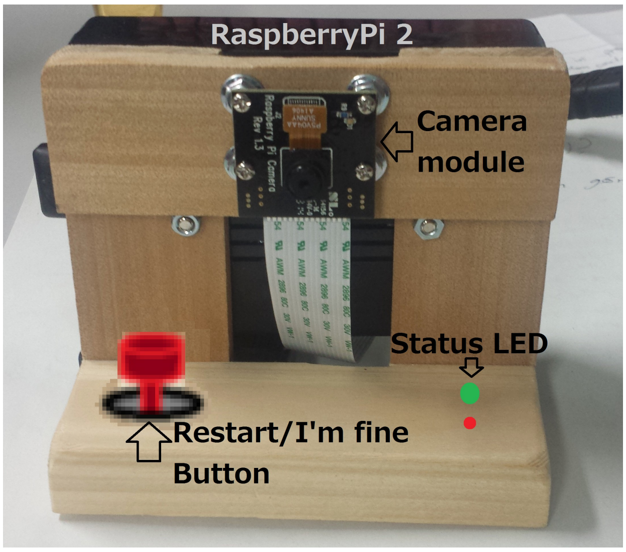


Illustration 2: Current state of prototype

5.1 Hardware

For the camera, a Raspberry Pi 2 model B V1.1[5] was used. But because the operations performed are quite light, a slower and cheaper version of Raspberry Pi could also be used. The camera used is a Raspberry Pi Camera Rev 1.3 module[5], packing a CMOS 5MP fixed focused lens. It's connected to the Raspberry pi using a dedicated Camera Serial interface (CSi).

For the cases when the power goes down a power-bank[4] with a capacity of 6000mAh is used. It takes about a second for this specific power-bank to switch from AC coming from a wall outlet to the internal battery. This leads to the RaspberryPi to restarting, but if the power comes back on again it switches automatically to AC power again.

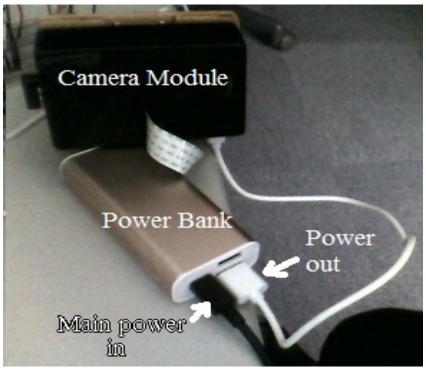


Illustration 3: Power bank set-up

This set up ensures that if the power goes out in the area due an earthquake, the system will maintain functional. A crucial function as the electricity almost always goes down in larger earthquakes.

5.1 Software

This section will go through the different software modules and their purpose. Everything in this section is developed in Python and runs on the Raspberry Pi.

JMA connection: The JMA has an API that allows for instant updates after there has been an earthquake in or near Japan. But their documentation is entirely in Japanese.

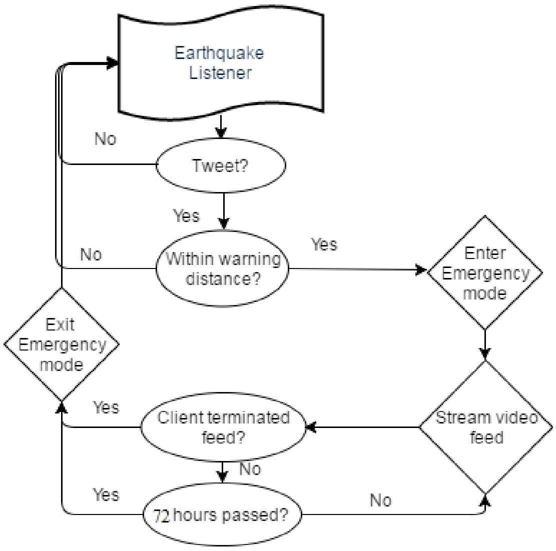


Illustration 4: Warning workflow

Luckily there is a Twitter[3] account called @quake_alert that tweets every earthquake recorded by the JMA. Therefore, it was easier to create a twitter bot that listens to @quake_alert and parses the tweet for information about the earthquake. The tweets contain among other things the longitude and latitude, depth, magnitude and time of the earthquake. From this the distance from the user can be calculated and what kind of damage can be expected in the users area. If the expected damage is high in the area, the device enters emergency mode and stays there until either the feed is cancelled by all clients or that 72 hours have passed. When the system enters emergency mode a picture is taken to show the state just before or during the earthquake just like a black box on an airplane.

Motion detection: The simplest form of motion detection was used, namely comparing pixel by pixel between two images taken a few milliseconds apart. Then if the percentage of different pixels is higher than a certain threshold, the system considers it as motion detected. As this is very CPU demanding for large images the pictures are taken in very low quality (64x64 image) making sure the CPU load never goes above 4%. Further improvements can definitely be made in this module.

Sound recording: If the camera has entered emergency mode, listen for human voices. If a voice can be heard, record that sound sample. If a connection to the internet is available try to stream the sound alongside the video.

Electricity handler: As previously mentioned the Raspberry Pi restarts if the main power source is turned off. Meaning that all states and operations are lost without the possibility to shut down gracefully. This handler ensures that all states are saved continuously and can be accessed on restart. It also keeps track of when there is an available network for the system. If there is no network available then Emsuch ensures that the music and video are not streamed but rather saved as files on the Raspberry Pi internal memory. If network comes back start sending the recorded files.

Socket connection: This is where the connection from the smartphone is accepted and then starts the streaming. The camera waits for an incoming connection if the emergency mode has been activated. TCP is used between the ends and the video is sent as h.264 encoded video.

Camera: If movement is detected take a picture and wait for a long time before taking another picture. If an earthquake has been detected and the system is in the emergency mode, start taking pictures with higher frequencies and stream video.

5.3 Mobile application

Android 5 Lollipop was used for creating and testing this the user side for this prototype. Though at this time and day, I have not been able to play the video stream from the camera on the Android device. The Android MediaCodec[8] and MediaPlayer[9] is claimed to work for this purpose, but as the documentation is lacking and all available functions are not explained I could not get it to work, yet.

So far the video stream can only be made visible by the user on a desktop application. This is done through connecting to a TCP socket on the RaspberryPi using an application named VLC[10]

6. Data collection results

In this study two people were interviewed over the phone, these people are survivors after big earthquakes that happened in Japan Mars 2011 and April 2016. As for the questionnaire around 60 people answered it to this day.

When looking at the current age distribution of the Japanese, the age class 70+ is about 19%[11]of the total population whilst in this study only about 5% were represented.

Age group	20-29	30-39	40-49	50-59	60-69	70+
Questionnaire	53.30%	15.00%	11.70%	6.70%	8.30%	5.00%
Japanese population	10.30%	12.50%	14.50%	12.20%	14.20%	18.80%

Table 1: Age distribution, measured in precentage of total population

The age class 20-29 stands for about 10%[11] of the Japanese population so that they account for more than half of the participants in this study makes this a bad representation of the Japanese population.

The reason for this might be that information about the questionnaire was mostly spread among contacts from the university. Another possible reason for this is that the older generation does not use the social media used to spread information about the study and questionnaire. Therefore, I took to the streets and asked older people about their opinion and had them filling out a paper form of the same questionnaire that was posted online. I also went to two retirement homes but there I could not collect the data immediately. So after this report is written more opinions will be collected and presented at the Iwate conference in early June. This is to ensure that the study group is representative of the age distribution in Japan.

6.1 Interviews

Both of the interviewed persons had experienced big earthquakes, the first person (Head Doctor at a nursing home, aged 74 years at the time) experienced the Tohoku earthquake of Mars 2011 and the second person (Post-Doctor at a biotechnology laboratory, aged 33 at the time) experienced the more recent earthquake in Kumamoto.

Starting with the head doctor he was at work in the nursing home when the earthquake struck. There wasn't any warning before the earthquake but he said that he could sense that it was an unusually large one. As the warning system from JMA used today was not widely used by the public yet, that he got no warning is not surprising. He couldn't move at all and had to hold onto a handrail to prevent himself from falling. His first concern was the residents of the nursing home, as he was the owner and the residents had just before the earthquake gathered for an afternoon coffee session. Lots of the residents in wheelchairs had fallen over and were injured. The power went out so the only source of information was a handheld radio. As he knew that his wife was safe as their house was located in a high enough place to not be affected by the tsunami. So the first time he contacted his wife was after a couple of hours when he wanted to tell her that he won't be coming home tonight and have to tend to the residents. He did that by sending an e-mail from his phone. The structure of his house was not damaged but all the roof tiles flew off and a bookshelf and other loose objects like a computer fell to the floor. He met his mother and oldest son a couple days later when he transported food from another town to the nursing home. They live in another prefecture further away from the epicentre of the earthquake so they were unharmed by the earthquake.

The Post-doctor was sleeping when the Kumamoto first earthquake hit and as the epicentre was very close the warning came at the same time as the earthquake. Meaning even if she would had been awake she would have had no time to prepare for the coming earthquake. Even though she did not see any news, she could understand that it was a big one from that it was very long, strong horizontal movement and loud sounds coming from the ground. The first thought was her own safety and she left the building immediately when outside she contacted her relatives directly. As it was impossible to call she sent an e-mail to them. She spent the night in a parking lot without any means sleeping. Then the next day she went into the house to get money, water, and other necessary items as well as turning off the electricity and gas. Several items like a bookshelf and the television had fallen over. Then in precaution for aftershocks she spent the night in a car, without being able to sleep. That night a second bigger earthquake occurred. As there were no water or electricity in the area she returned to her parent's house in Sapporo which unaffected by the earthquake.

6.2 Questionnaire

A thing that was very clear from the questionnaire was that if Emsuch is used almost no one has any problem with sending the collected data to rescue operations directly. Only 3% of participants did not want to send the data to the rescue teams. The concerns were that the data might be used for something other than the intended purpose and how much of the daily life could be seen in the data sent. But the majority wanted to send the data, mostly because if their life was on the line their privacy comes in second.

Question	Yes	No	No Answer
Do you want to send data to the rescue forces?	95.00%	3.30%	1.70%
Could you consider using this system?	66.70%	30.00%	3.30%
Do you see any problems with this system	36.70%	16.70%	46.70%
In case of an earthquake, do you try calling first?	70.00%	20.00%	10.00%

Table 2: Questions from the questionnaire and answers

There was no convincing trend among the answers depending on the living status of the participants. Most of the participants lived with someone from their family, among a third lived by themselves.

When asked about possible problems, among those who answered yes about half of worried about security, if the system could be hacked or if someone could access their data without consent. The other half worried about their privacy, and how much of their daily life could be seen from the camera.

About 62% of the participants had and used a smartphone, though this might not be a true representative of the Japanese inhabitants. As mentioned earlier the age group 20-29 was over-represented, which might be behind the relatively high usage. But if the high usage is still true when a more real distribution is achieved, then we can assume that using a smartphone application as a receiver for this kind of system is feasible.

About 46% of the participants started to worry about family members around a level 5 earthquake, the rest of participants ranged from level 3 to 7 for when they start to worry. It seems like it depends strongly on the person.

For means of contact when there has been an earthquake 70% of the participants first tries to call directly. Then the second biggest category was sending an e-mail, either from the mobile phone or from a computer. Only about 11% of the participants tries to use applications such as Line, Skype, and other online chat applications. 10% of the participants also tries the emergency service (calling 171) if they can't get through directly.

As this system just is a draft and highly flexible with the possibility of adding additional functions and modules the participants were asked if they'd like some other function from this system. The answers were varied but some reoccurring answers stood out. For example implementing some speaker, either to be used as an early earthquake warning or to notify the surrounding with high sound if there is a person trapped in the house. Another example is adding sensors so other kinds of disasters can be detected, as smoke and temperature detectors for fire. Robust security was also mentioned a couple of times, to ensure that your private data can't be accessed by strangers and possible ill-doers.

When asked about who to send the information to most of the participants (about 75%) answered that they wanted to send it to family members. Only a few (about 13%) could consider sending it to friends.

7. Discussion and conclusion

The person from the first interview didn't worry about his family at all, there seems like there was no need for a system like this in his case. In the case of the second interviewed person, there could be a need for this kind of system if her parents were worried about her. But as she left the building immediately after the first earthquake hit,the parents might rather see her leaving than a live stream showing fallen over furniture and shelves. But the interviews proves that even though they tried calling first they couldn't contact their relatives directly and turns to sending a message over the network instead. Meaning the system could handle the process of contacting the relatives and saying they are unhurt automatically while the victims can focus on their first thought, their own safety or other victims safety.

Another interesting point is that the Post-Doctor went inside to turn off the electricity to prevent the outbreak of fire. Being able to turn off the electricity the person living in the house is probably fine and is moving around. Before turning off the electricity pushing the “I'm OK” button on the system will ensure that everyone connected to the system will know that their relative is not severely injured. But turning off the electricity might complicate things for the device. If the device needs to consider possible aftershocks, it needs to still be running and awaiting warning updates from JMA. But if the main power is turned off the device may need to run on its battery for a day or two. Meaning the original assumption made in this report that the battery only needs to work for about 6 hours was completely off.

At what seismic level Emsuch should start to warn people in the area about an earthquake and turn on the camera was not clear. As the answers collected from the questionnaires was spread out over a broad spectrum. But as level 5 in Japanese seismic scale was the biggest category this will be the default value. Though as it differ from person to person the warning level should be adjustable. Ensuring that the camera doesn't turn on if there is no need for it to.

As expected the majority of the participants tries to call directly to each other if there has been an earthquake. But what was surprising was that even though that the majority of the participants was of a younger generation only a few tries to use chat applications. As the networks are more resistant against bursty traffic, communication over the network should provide a higher chance that the family members can contact each other. A reason for this might be that it takes a longer time to write and respond in text, than if the call is connected. So even with the over-representation of younger Japanese, the results show that very few Japanese use an application for communication.

As there was a consensus that the data should be sent to the rescue forces in order to find missing people faster, there may better to shift focus to trying to send the data toward a rescue force instead of family members. Thus having family members or friends receiving footage from this device to be optional while the system is by default connected to a rescue force.

To conclude this study we look at the two questions asked at the start if this system is useful and if older generations could consider using it. Regarding the usefulness of the system, we have seen that it might be useful in some situations where the first and only focus of the victims is their own survival. The system would then automatically tell your relatives that you're fine. As for finding a person under the rubble of fallen house, this system is not deemed very useful. Mostly for if there is only a live stream available it is impossible for the users to know what happened their relatives at the time of the earthquake if they gain access to the video feed a minute later. Their relative might be under the rubble but could also have made it safely outside.

Regarding the adaptability of the system to the older generation, it seems like few elderly even have a phone capable of receiving a video stream. But the question then is do they really need to? If the older generation installs this system in their home, their younger children can still know that the older generation is fine through their device. And for the other way around, maybe an interface or device can be set up in the elderlies home letting them see if their children are safe after the children have pushed the “I'm fine” button on the Emsuch.

8. Future work

After this report, this system will be further developed. But the focus will shift more into networking and how to send the data. This is because even though this system may be useful and help in disasters, it may also cause important communication to halt due to filling the bandwidth with video. So for this solution with a camera in the house to become a reality, the systems affect on the network needs thorough research. Ad-hoc networks[7] might be a good idea to maintain contact with the infrastructure, but how to implement the networking within the ad-hoc network will probably an area of interest later on.

Another possible work direction is focusing more on what information the users wants about the victims in the earthquake area. Stuff like adding image processing to know when there was a person in the room might be interesting for the user.

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