Robots Collaboration based on Cloud Robotics System for Daily *Emergency Life*

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Abstract: A person should solve unpredictable problems and evacuate from difficult emergency dangers by himself/herself. These days many different tasks can be solved by robots. However difficult tasks need more information in serious changing environments and human minds which are shared by robots and cloud servers can achieve this greater information. We propose a robot collaboration methodology in a cloud robotics computing system that can enable a robot with few resources to solve the difficult problems in both human daily life and emergency situations and provide users with useful awareness. We discuss how robots collaborate utilizing cloud robotics capabilities in order to exchange data/contexts and to find candidate solutions and create maps for emergency evacuation. We also discuss experimental results by a prototype of robot system for daily/emergency life.

1 INTRODUCTION

A person should solve unpredictable problems and evacuate from difficult emergency by himself/herself. Nowadays, robots are not only toys for children, but they are also useful tools for people of all ages in many situations. They are useful for health rehabilitation, rescue, robots for dangerous tasks, housekeeping robots and so on. Over the past few years in the field of information technology has evolved a new paradigm - cloud computing. Although cloud computing - a special way to provide computing resources has caused a revolution in the methods of providing information and services. A similar revolution in collaboration between robot and human utilizing the cloud computing that is called "Cloud robotics" (James, 2010). A robot with sensors and actuators interacts with the environment. Sensor data become useful feedback for making decisions of next effective action of the robot. This reduces the load on the computing power of the robot, as well as reduces the cost of the robot. Maps of sensor data show the locations of robots and some contexts in the serious environments. We discuss an autonomous robot in daily life as well as in emergency situations, like an earthquake, based on the cloud robotics. We also discuss experimentation by prototype of autonomous robots.

2 EMBEDDED INFORMATION IN DAILY LIFE AND EMERGENCY TIME

Inconvenient information for a person is often concealed in daily life even in ubiquitous computing society. People can acquire a limited volume of useful information in a disaster. Humans need intelligent assistants in order to remind them of important issues and solve suspended problems.

In the case of daily life, the parents should look after the child, although they are very busy and are not always able to find the change in their child's grades. Some children don't want to tell their parents about their grades or in another case some of them can just forget to tell their parents about the note from their teacher. Skipping this information will be a problem for the children's study, because parents can think that their children go to the school every day and everything is fine with them. In this daily life situation a robot will be useful for the people.

In case of disaster situation it's very vital for people to be informed to quickly evacuate from a

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dangerous area. Some human nature has negative effect such as panic, "normalcy bias," "catastrophe forgetting" and this will be reason of making mistakes like wrong staying zone(not safe), not effective route to get to safe places. Some people are thinking that their place (house) is strong and it isn't necessary to be evacuated. Robots with cloud can be an intelligent assistant for humans. We discuss robot rules in order to avoid these problems by providing real-time information and to help people get to the safe please as soon as possible.

3 ROBOT COLLABORATIONS AND AUTONOMY FOR EFFECTIVE SOLUTIONS

Robot network system has two sets of collaboration frameworks in (A) daily life and (B) disaster evacuation.

A robot should acquire trust from its owners, and it should also contribute to the owners in both cases (A) and (B).

A robot has mainly six kinds of "Autonomy" for both daily life and emergency evacuation.

Daily Life. (1) Relative analysis, (2) Best solutions in each field, and (3) creation of motivation.

Emergency Evacuation. (4) Universal solutions in all approaches, (5) Embedded information, and (6) Psychological assist

3.1 Daily Life Awareness: Learning Management by Relative Analysis

A student should have good motivation and actively proceed in his/her learning. When a student gets low grades on their examination a personal robot discovers weak points of its owner, like serious results on a test and can autonomously find good reference books and tutors in the cloud servers corresponding to the level of serious grade. It will keep communication between teachers and parents open. The robot acquires the latest grades and analyzes contexts of changes of the grade. The robot also autonomously analyzes the reasons of the serious grade of the student based on the change of grades of the student's friends. Then the robot suggests these solutions to the parents:

If the result of the examination is worse than 1-30 %, it recommends a list of textbooks for improvement to help the student prepare for the next exam. The robot makes a request list of textbooks from cloud robotics.

If the result is worse in the 31-50 % that gives a list of tutors number 1, with a score worse than 51-100 % is another solution that can be given to parents by the robot to improve the test results of the child.

The parent can consult with the student utilizing candidate solutions. Daily assessment of students, teacher's notifications, school events will be saved in the cloud robotics. Related with the student achievements the robot will give advice to parents by analyzed data. It will be easier for parents to be informed about their children at the school. (see Fig 1).

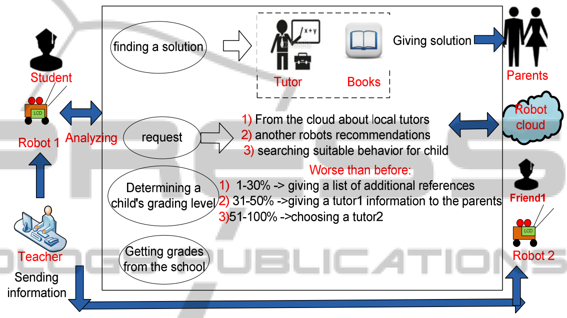

Figure 1: Learning management by robot collaboration.

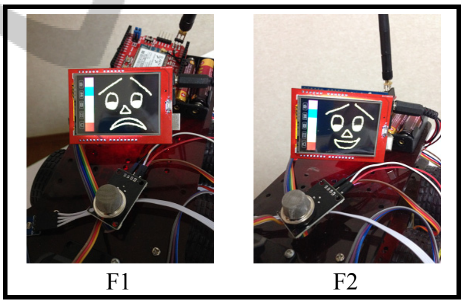

Figure 2: 80 faces of robot. Emotions such as F1 (joy 1.0 and sadness 0.4) and F2 (joy 0.4 and sadness 1.0).

3.2 Emergency Awareness Avoiding Danger

3.2.1 Communication between Robots and the Cloud by using Clone-based Model

Flexible adaption against sudden attack of disaster need autonomous actions of each robot. We propose "Clone-Based Model" for collaboration between Robots and cloud with redundant servers (see Fig 3).

"Clone-Based Model: each robot has a corresponding system- level clone in the cloud. A task can be executed in the robot or in its clone. The set of robotic clones also form a peer-to-peer network with better connectivity than the physical ad-hoc M2M network. Moreover, this model allows for sporadic outage in the physical M2M network" (Guoqiang, 2012).

Robots and cloud share the data and history of the data. The shared data enables them to analyze Big Data.

For example, serevers in Tokyo would be broken by a disaster. Then the robots can send and receive information from the server in Osaka . Parallel backup data is necessary because we can not imagine the destructive force of the earthquake . Robots R1 (west area), R2 (east area), R3 (north area), R4 (east area) are in the local area and should autonomously detect risks and share them. (see Fig 3).

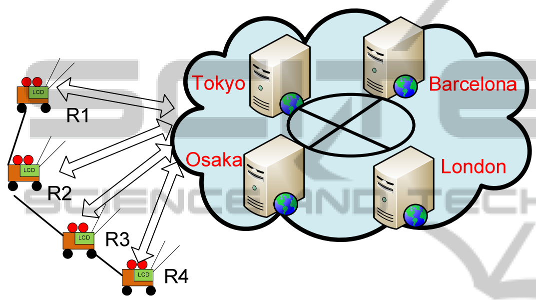

Figure 3: Clone-Based Model of robot collaboration system.

(rc1) All robots will upload new sensors data to the cloud. In parallel all servers(clones) will get new sensors data from the robots.
(rc2) The cloud will collect real- time photos of situatuions and can send these to the robots.
(rc3) The robotic cloud computing will make an evacuation map in accuracy by using data from the J-SHIS and the robots.
(rc4) By using updated data the robotic cloud computing can prepare an optimal route for each robot's owner.

Robot and cloud robotics have reliable management functions of change of context in each field. It has three historical types of data: "old", "current" and "new"(see Table 1). In a disconnection situation case the robot gets new data at its current place from the cloud it also takes the latest data of the other 100 related objects from the cloud robotics.

Table 1: Data states during disconnection situation.

	robot	cloud
Old data	1	1
Current data	1	1
New data	0 ⬅	1

(1) Robot Assists based on Cloud Information. Evacuation Guide. Robot uses two types of earthquake sensors. A swing sensor in its body and P-wave sensor attached to a wall or fixed pole. P-wave sensor detects the first wave (P-waves) of an earthquake. This p-wave sensor data from "Quake Alarm" device will send to the cloud by WiFi modems. The robot responds to the previous earthquake compression waves which are inaudible to humans because the frequency of the wave is less than 20Hz, just animals can react to this type of wave. The robot analyze two kinds of sensor data by inner swing sensor, P-wave sensors, and general data from J-SHIS, and make a quick decisions for evacuation's actions from a wide area point of view.

J-SHIS can provide a general evacuation map. In case robot they can give information about real-time safety places. These two maps will be different. Because in general evacuation map they are 5 nearest safety places with routs, but some places can already damaged and the robot "A" will send this damage to the cloud. By comparing two maps the cloud can make decision and provide evacuation map with effective routs. Also most of residents may not know second safety place. The robot will be used as an evacuation guide with evacuation map. Most Japanese people think it is not necessary to evacuated before/after first wave of earthquake since Japanese houses are usually strong for seismic activity. They stayed in the houses.

Rules of robots during earthquake:

I. Providing information about the first wave and the next wave of earthquake
II. Reducing psychological forgetting (panic) of people
III. Making evacuation map and effective route to safety place by using big data from the robotic cloud.
IV. Providing real-time information about local area to people and J-SHIS.

(2) Normalcy Bias. In The Great East Japan earthquake about 70 % of residents did not evacuate although they knew the tsunami warning of the government in text and reading out by an announcer. That is why only giving warning of tsunamis is not enough since the citizens have been safe for 38 years. They believe it would be enough that only playing no serious damage by tsunamis. They need to acquire the motivation and chance to start evacuation from the giant tsunami.

Visual information allows residents to quickly understand serious situations and to make the decision to leave their houses. Such photos/video (see Fig. 6) of running to the safe place enables residents to avoid psychological disorders such as normalcy bias and catastrophe forgetting (Miyachi, 2013) and quickly start evacuation in the safe direction. We propose 5 seconds duration video (photos) that show evacuation actions by people who already have evacuated in real-time by the robot. To avoid this kind of psychological problem the robot can change faces corresponding to the degree of an impending earthquake (see Fig. 2) (Schmitter, 2008) and also showing real-time pictures from another robots about people evacuation.

(3) Contribution to Japanese Earthquakes. Earthquakes usually cause fire, since Japanese houses are built by wood and there are many restaurants in the towns in a same street. If strong winds expand the fire over the first shelter, residents should change the place of refuge from the first safe place to the second safe place and know safe routes to get there. Most residents do not know such information. The robot should show the residents the second safe place and the safe route while sensors of robot are detecting dangers for safe mobility to the safe place. Fallen concrete block, fire in the old wooden houses, road collations, and evacuation ability of aged persons should be provided by the robot and knowledge in the cloud servers.

(4) Contribution to Kazakhstan Earthquakes. There are a lot of industrial companies in Almaty city (see Fig. 4). Each of them can become flammable zones (green icons-flammable zones and blue icons-safety places, yellow icon -person's house). In case of a person's house being near the industry area the robot would recommend to go to the place "A0" considering the strong north wind. Robot could find a safe direction and safe places to evacuate based on the direction of the wind from server of "National Hydrometeorological Service of the Republic of Kazakhstan". Robots should have "decision table for safe direction/safe place" in order to quickly find them. The decision table becomes an explanation of why the decision would be the best solution.

3.2.2 Collaboration between Robots without Cloud

This communication allows robots connect with each other without cloud access point by wireless communication, such as WiFi module or WiMax etc. The Robot R1 is near dangerous are (fire,gas etc) R1 will send a request about area to the friends robot R2 (neareast robot). If the R2 will be near not safety place , the R1 will recomendate to an owner to leave area near R1 and R2.

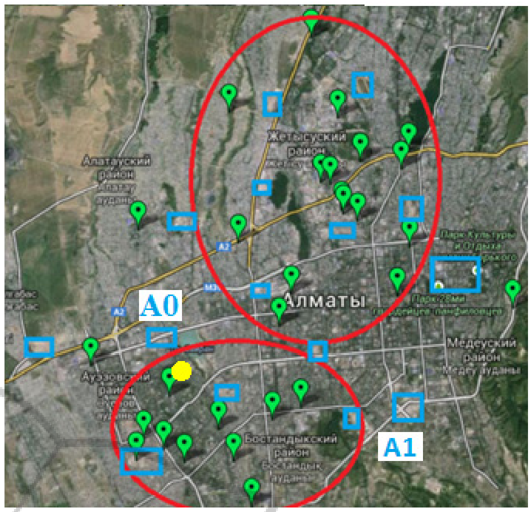

Figure 4: Google map. Almaty city with flammable zones.

(rr1) A robot autonomously gets sensor data and detects danger.
(rr2) A robot communicates with a robot near it and checks whether the other robot has similar situation or not when it detected the danger.
(rr3) A robot also sends the other robots awareness of such danger that it detected.
(rr4) A robot shows its owner awareness with the information from the robot that detected the danger.
Data exchanging between robots without the cloud is should be simple to save memory and computation resources. Robot R1 will get data from robot R2 in a table. The table includes information: which robot (ROBOT_ID), in which area (AREA_ID), has what kind of situation (earthquake, tsunami, fire etc) (SITUATION_ID), when (TIME), what is data (DATA) and situation level (DANGER_LEVEL).

A good point of this communication is that it enables robots to autonomously find specific areas and minimal additional computation and memory resources.

4 EXPERIMENTS

Experiment 1. Learning management by Student's Grade. The robot found good reference books and a tutor for the weak points of the student based on collaboration with friend's robots through the cloud robotics system. The robot could recommend the parent the best reference books and the tutor for characters of the child.
Subjects: International Students (between 24 and 33 years old)

Question1. "What kinds of recommendations (A: books, B: tutors, C; books and tutors) do you give for each cases of students to improve their grades?"
Case 1: one student's grade decreased and the other student's grades did not change
Case 2: Half of the student's grades decreased and other student's grades did not change
Case 3: All students' grades decreased.

We found that all international students expect to get tutors and books in case 3. In case 2 we see that about 70% of subjects needed good tutors although half of subjects decreased the grades. We could make sure that the awareness with candidate of tutors for parent would become useful in case of both case 3 and case 2. International students might be very sensitive for decrease of the degree. More than 63% of the students can study by themselves in case 1.

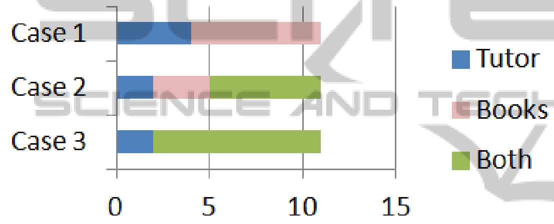

Figure 5: Preferred awareness for the level of grade.

Experiment 2. Avoiding Psychological Disorders

As we discussed in section 3 about providing real-time video (photos) with name of area by different areas robots it will be shown on a TFT LCD as in below figure 6.

Figure 6: Simulation showing photos in case evacuation.

Experiment 3. Autonomous robot detection based on crone model. The types of sensors are fire, gas, rain/snow, ultrasonic, and shaking (see Fig 7).

The robot could detect fire, gas, rain/snow, ultrasonic, and shaking (see Fig. 8).

All sensors (see Fig 8) were attached on the Arduino Uno board. Arduino is a hardware computing platform, the main components are simple input-output board and a development environment for language Processing/ Wiring.

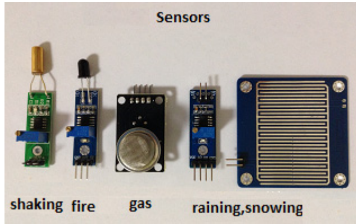

Figure 7: Sensors.

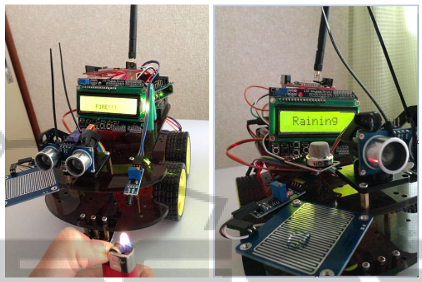

Figure 8: Detecting fire and rain .

Programming language is C. Initial step of experiment was with fire, raining sensors. Fire detection is necessary for emergency situations to avoid flammable zones. Robot showed messages such as "No fire"/"Fire". Rain detection is also useful to analyze weather in case of fire situation can be changed. "No rain"/ "Raining" on the LCD display corresponding to the rain detection.

Experiment 4. Emergent Awareness between Robots. We experimented communication (data exchanging) between the robot and computer with fire sensor through Bluetooth channel. We used for the robot a "Slave HC-06 Wireless Bluetooth RF" module to send sensor data to a computer terminal and for the computer "Tera Term" a terminal emulator. When the robot could detected fire (see Fig 8) on the Tera Term we see text "Fire area" in case detecting "no fire" on the terminal we see the text "Safety" (see Fig 9). In the next step a Bluetooth module will be replaced with WiFi module also instead of a terminal emulator we will use a web server.

5 CONCLUSIONS

In this paper we propose robots collaboration system based on cloud robotics that provides useful awareness for unpredictable problems. We discuss how robot collaboration works in both daily life and emergency life. We also discuss six kinds of robot autonomy and awareness based on relative analysis.

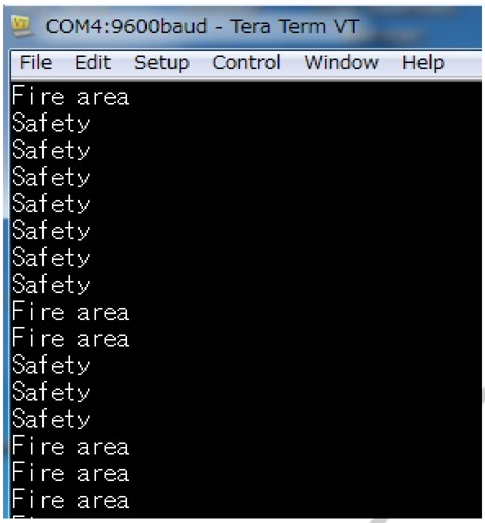

Figure 9: Tera Term is getting signals from the robot's fire sensor through Bluetooth channel.

We made a prototype of a robot system. By detecting fire/dangerous gases and sending these signals to the computer via Bluetooth channel. In addition, we did simulations by creating various faces for the robot that can be used to express the robot's emotions depending on the situations and changing real-time photos on TFT LCD to avoid human psychological disorders.

Our next step will be by using "p wave" sensor to detect the first wave of earthquake and sending this signal to the server by using SainSmart WiFi Wireless Shield WizFi210. Also we will make a second similar robot to test collaboration with each other. Then we will check how the robot will make an evacuation map by using data about the first wave of earthquake and signals from other sensors like radiation etc. from the server. Also we are going to use emotion recognition with Kinect and voice recognition system that the robot can understand voice commands.

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