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Information acquisition using intelligent sensor nodes and an autonomous blimp

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Abstract: In case of disasters such as a big earthquake in the urban city, it is one of the most important problems to acquire information of the disaster environment, victims' position and status. Although, at present, rescue corps and dogs strive to find the victims everywhere in the disaster area, it takes too long time. To address this problem, a small sized wireless ubiquitous sensor node called "Rescue Communicator" is developed. Rescue Communicator can call to the missing victims possibly trapped under rubble and record their voices if any so as to efficiently find them immediately after the disaster. Installed indoors prior to the attack of a disaster or placed in the disaster-affected site after the attack, the devices under development are capable of forming an ad-hoc network throughout the environment around the site. This works in parallel at the disaster site (ubiquitously searching) and supports that rescue corps search for the victim, effectively. This paper will discuss about outdoor basic operation experiment of Rescue Communicators which cooperate with blimp.

Keywords: sensor network, ubiquitous sensor node, ad-hoc network, blimp, rescue robot

1. VICTIMS SEARCH SYSTEM

The objective of this study is to build a victim search system with a small wireless communication device capable of calling to missing victims possibly trapped under rubble and recording their voices. It enables the rescue corps search for persons to be saved at all once over the whole disaster site (ubiquitous environment) and immediately collect on-site information using flight vehicles like a blimp. Being developed devices can also support efficient rescue-activity such as to building up wireless information network at the disaster site.

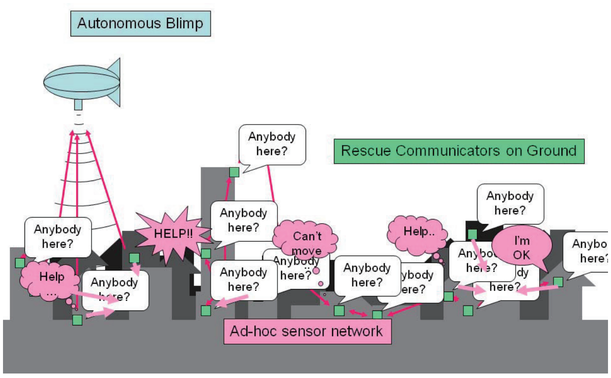

Fig. 1 victims search system

To achieve this system, fundamental specification requirements of Rescue Communicator (R-Comm.) should have been defined.(table1,Fig.2) The R-Comm. is intended to record the voices of victims in the disaster area and upload the stored voice information onto the blimp traveling in the upper air to provide information useful for the Disaster Management Center to take its backup activities. The R-Comms must have been installed at arbitrary positions such as in a ceiling beforehand. The R-Comm. also has implemented the functions for initiating recording of the voice or sound in the rubble at arbitrary times in response to a start-up signal sent by the blimp traveling about 50 [m] above the ground and for uploading the stored voice or sound information onto the blimp within one second. Moreover, in the experience of Hanshin-Awaji Earthquake it must be equipped with a battery for continuing to operate as long as possible even under the environment in which no electric power is supplied.(ideally speaking, over 72 hours). The R-Comm. is designed to cycle mainly through the four states described below to search for the victims possibly trapped under rubble for a long period.

Table 1 Specification of Rescue Communicator

CPU	Renesas tech. SH4 (100MHz)
Memory	32MB
Extension slot	Compact Flash * 3, RS-232C * 2
Communication	Wired/ Wireless LAN, InfraRed, Modem etc.
Other Interface	Speaker / Microphone / Parallel, etc.
Size	87.5x142.5x79.0(long)87.5x92.0x79.0(short)
Acting time	4hours(continuous) 72hours(intermittent)

Fig. 2 Rescue Communicator

2.1 Rescue Communicators on ground

Each R-Comm. records a sound five seconds every minute. The sound is translated to XML file which consists of MP3 (32kbps)-encoded sound, time, position, ID, etc. The XML files are transmitted to blimp using ad-hoc network when it comes in the communication area of the R-Comm. The XML Schemas (sensedDataInfo and sensedDataEntity) are designed by Noda[4]. Samples are shown in table 2 and 3.

Table 2 Sensory data format which is based on mitigation information sharing protocol (MISP)

```
ddt:sensedDataInfo
+ddt:location: ddt:LocationPropertyType
+ddt:validTime: ddt:TimePrimitivePropertyType
+gml:using: gggd:SensorInfoRefType
+[gml:target]: gml:TargetPropertyType
+gml:resultOf: gml:ResultType
+[gml:direction]: gml:DirectionPropertyType
+ddt:notes: AnyXML

ddt:sensedDataEntity
+<gml:id>: URI
+ddt:type: MIME Type
+ddt:encoding: string = [plain | base64]
+ddt:data: string or AnyXML
```

2.2 Collection device and autonomous blimp

Collection device consists of radio-shielding Linux-PC, WLAN card and directional antenna. (Fig.3) Communication physical speed is 11Mbps and its area is about 300m, plus or minus 30 degree thanks to directional antenna.

Figure 3 collection device

Table 3 Sample XML which stores mp3 sound


```
<ddt:sensedDataInfo xmlns:ddt="http://staff.aist.go.jp/i.noda/DDT/0.0"
  xmlns:xlink=http://www.w3.org/1999/xlink
gml:id="http://bosai.nict.go.jp/~had/080128/sound02.mp3.info">
  <ddt:location>
    <gml:Point>
      <gml:coordinates>-50.000000,-50.000000,0.500000</gml:coordinates>
    </gml:Point>
  </ddt:location>
  <ddt:target>
    <gml:Point>
      <gml:coordinates>-50.000000,-50.000000,0.500000</gml:coordinates>
    </gml:Point>
  </ddt:target>
  <ddt:validTime>
    <gml:TimePeriod>
      <gml:beginPosition>2008-01-28T18:00:00+09:00</gml:beginPosition>
      <gml:endPosition>2008-01-28T18:00:00+09:00</gml:endPosition>
    </gml:TimePeriod>
  </ddt:validTime>
  <ddt:using xlink:href="R-Comm_2008"/>
  <ddt:resultOf xlink:href="http://bosai.nict.go.jp/~had/080128/sound02.mp3">
    <ddt:type>audio/mpeg</ddt:type>
  </ddt:resultOf>
  <ddt:direction>
    <ddt:DirectionVector>
      <ddt:horizontalAngle>0.00</ddt:horizontalAngle>
      <ddt:verticalAngle>-0.08</ddt:verticalAngle>
      <ddt:rollAngle>0.03</ddt:rollAngle>
    </ddt:DirectionVector>
  </ddt:direction>
</ddt:sensedDataInfo>

<ddt:sensedDataEntity
xmlns:ddt="http://staff.aist.go.jp/i.noda/DDT/0.0"
  xmlns:xlink="http://www.w3.org/1999/xlink"
gml:id="http://celultra.riken.jp/~koguchi/060128/sound02.mp3">
  <ddt:type>audio/mpeg</ddt:type>
  <ddt:encoding>base64</ddt:encoding>
  <ddt:data>
SUQzAwAAAAARR1RJVDIAAAAbAAAAg16DQ4Nng4tObzAwM
SAtIDIwMDYtMDEtMjZUQUxCAAAA
DQAAAINBg4uDb4OATm8xMVRZRVIAAAAFAAAAMjAwNVR
DT04AAAAiAAA....
  </ddt:data>
</ddt:sensedDataEntity>
```


The aerial vehicle consists primarily of an airplane, helicopter, or blimp. Table 4 provides the characteristics of the three types of aerial vehicle. Airplanes and helicopters are comparatively noisy, and their noise and wind blasts would create problems and hinder rescue activities in stricken areas. A blimp is a better choice for victim searches, as it hovers and moves slowly, silently, and safely.

Table 4 Characteristics of aerial vehicles

	Stability	Noise	Hovering	Vertical takeoff	Turn	Velocity	Body	Wind
Blimp	yes	silent	yes	yes	small	slow ~middle	huge	week
Plane	no	noisy	no	no	large	high	small ~huge	not week
Helicopter	no	noisy	yes	yes	small	slow ~middle	small	not week

We verified the effectiveness of the system using autonomous blimp which JAXA had developed. (figure 4) The specification is shown in table 5. Collection device is installed on lower side of the front of the blimp. Collection device transmits seek command to the ground constantly. When R-Comms are in the communication area, they reply and transmit XML data.

Table 5 specification of experimental blimp

Length	14.0m
Width	4.8m
Weight	105.6kg
wind-resistant speed	15m/sec
endurance	2hours
payload	More than 3kg
altitude	Used normally under 100m
power	2 reciprocating engines
Driving mechanism	Ducted propellers
fuel	gasoline (max20litter)

Figure 4 experimental blimp

Figure 5 Collection device installed on the blimp

2. OUTDOOR EXPERIMENT

The outdoor experiments were done on August and on December 2007. We set three R-Comms on ground. One of them didn't work due to computer trouble, however the other two sent XML data to the blimp. As a result, voice information that R-Comms on the ground had collected were able to be transmitted to the unmanned blimp that flew 50 to 100meters height. The result shows the effectiveness of the proposed system that deals with simultaneous acquisition both of detailed information on ground and of global information from the sky.

We also investigated if blimp can communicate with R-Comm in various materials. As a result, communication speed decreased, however it could receive the data from R-Comm. in concrete box, wooden box and iron box.

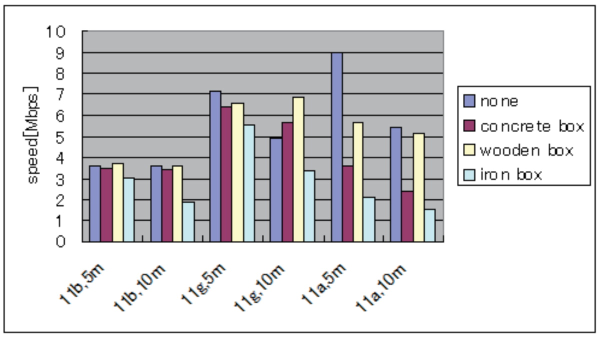

Figure 6 WLAN speed with obstacle materials

3. FUTURE ISSUE

We will examine the robustness of the communication in various conditions of agent's speed and height. Various kinds of disaster environments (ex. typical crashed wooden house, brick and concrete building).

Helicopter, airplane, mobile robots and human also can be used as communication agent, though we used blimp in this experiment. We will examine the capability of our victims search system using the various mobile agents.

4. CONCLUSION

We describe about our remote sensor network in disaster. As a result of outdoor experiments, R-Comm on ground could transmit sound data to autonomous blimp in sky.

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