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Proposed idea for monitoring the sign of volcanic eruption by using the optical frequency comb

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Abstract - *Volcanic eruption is a natural disaster which causes many problems including deaths. Before happening the volcanic eruption, the temperature of the gas comes out from the fumaroles is increased. Thus, if the temperature of the gas can be monitored in advance, it may be possible to predict the abnormalities in that area. The possibility of volcanic eruption could be inspected by using the optical frequency comb technology monitoring the refractive index. The temperature of the gas that comes out from the fumaroles will be continuously monitored for investigating the possible risks of the eruption in near future by using the proposed optical comb method.*

Key Words: **Volcanic eruption, temperature, gas, refractive index, optical comb**.

1. INTRODUCTION

Volcanic eruption is a natural incident which may occur any time and usually it costs many deaths and damages at the surrounding areas [1]. The amount emitted of lava determines the size of volcanic eruptions. The active volcanoes are located in vastly populated parts in some countries such as Italy, Japan, and Mexico [2]. Among these countries, Japan, one of the most developed countries, is located on the circum pacific orogenic belt and it has 108 active volcanoes which are 13% of active volcanoes all over the world [3]. Distribution of volcanoes and volcanic arcs in Japan are depicted in Fig -1 [4].

A sudden volcanic eruption of Mount On take caused the deaths of 57 people in Japan on 27th September 2014. Fig -2 shows that the volcanic ash is going to envelope the hikers [5].

For decreasing the risks of death and damages, noteworthy developments are needed to make an accurate prediction of volcanic eruption in advance. There are several techniques for monitoring the volcanic eruption.

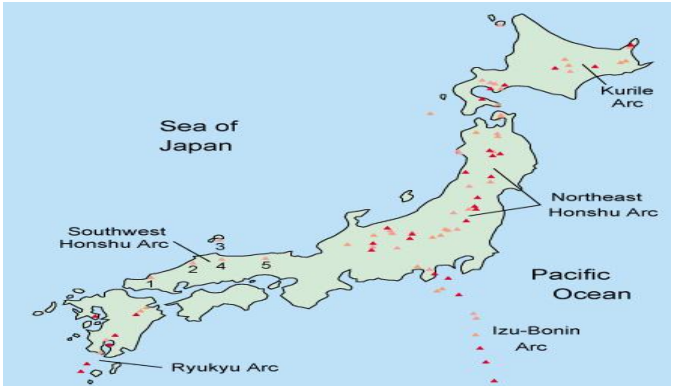

Fig -1: Distribution of volcanoes and volcanic arcs in Japan [4].

Among them, the most common technique is analyzing the seismic data by installing the seismic sensors [6]. However, the seismic data is not enough to be considered as there are many other geological factors needed to be investigated. There are other monitoring methods including the study of deformation and monitoring the gases that come from fumaroles. Monitoring the change of temperature of the gas seems comparatively easy and the abnormal increase of temperature might be a mark for the volcanic eruption.

Fig -2: Volcanic ash envelopes hikers [5].

The optical frequency comb is a key tool which has significant roles on different applications such as generating ultra-short pulses, optical clocks, optical spectroscopy [7], correcting air refractive index [8], distance measurement [7,9], air refractive index and carbon dioxide measurements [10], etc. It was mentioned earlier that, monitoring the temperature-change of gases could be effective for the volcanic eruption and the temperature-change measurement using optical frequency comb was demonstrated in [11].

Hence, by using the concept for observing the change of temperature, the investigation of the sign for volcanic eruption can be done with added technology.

2. EXPERIMENTAL SETUP AND DISCUSSIONS

This paper is a proposed study for volcanic eruption with the concept of the [12]. Fig -3 shows the proposed experimental setup for the temperature measurement. This setup can be implemented for the prediction of volcanic eruption. The operation principle and the experimental setup are described in [12] which are based on Michelson Interferometer.

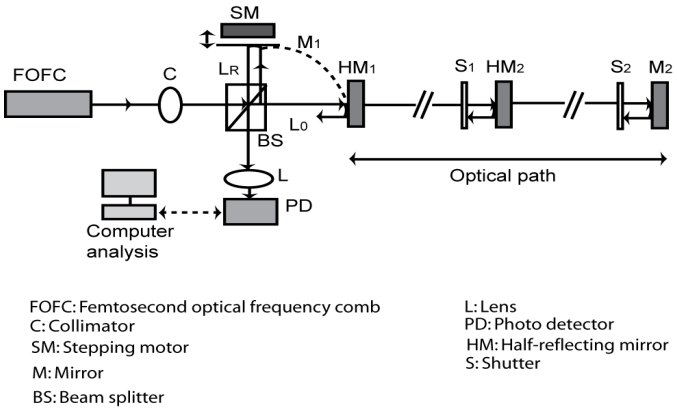

Fig -3: Experimental setup of temperature change measurement [12].

The refractive index of air changes with the temperature, as an example, when the temperature around the air changes by 1 degree Celsius, the amount of change of refractive index is about 0.9 ppm [11]. As a result, the relative optical path difference is also changed. The gases leak from the fumaroles of the active volcanoes to the surface and if the temperatures of the gases are monitored by using the comb technology continuously, the sign for any possible volcanic eruption may be observed.

For measuring the temperature, refractive index or distances, the optical comb technology is used in a very stable and compact environment, however, investigating the sign of volcanic eruption using this optical comb technology may be difficult as there are severe environmental changes occur on the mountains. Hence, lots of studies and investigations are needed for reference data for comparison. For example, the temperature for different situations like heavy rain, light rain, heavy snowing, light snowing, seasons-change, day and night time and others must be recorded to compare with the experimental data. Otherwise, only observing the change of temperature will not be effective to find out the actual reasons. The piping could be employed from near the fumaroles to the setup to try to reduce the other effects for the change of temperature.

Another problem would be installing the power supply for the laser at very high places of the mountains, for example at around 3000 meters or above. Implementing the solar panel could be a good solution for the power supply to the temperature-sensor setup.

Remote sensing technology is needed to monitor any environmental changes or measurements from far distance. Programmable and remote devices can be added with the computer in Fig -3, hence the data can be received and analyzed remotely from far. As an example, microcontroller based remote sensing using cellular network can be very useful for monitoring the sing of the volcanic eruption. The programmable device, for example, the microcontroller will be connected with the computer and it will receive the data from computer. The microcontroller will send the data using the cellular network continuously or when it is requested to send the data. However, if the computer will be connected with the internet directly, the data of the computer can be accessed directly from the remote sites. Remote sensing and monitoring using microcontroller under the cellular network was demonstrated in [13]. Fig -4 Shows The Light emitting diode (LED) is remotely switched on using the cellular network [13] Thus, these kinds of technology would be introduced to monitor the area if any network is available.

This paper shows the several possible applications and there how microcontroller deals with temperature has been shown.

We know that,

98 F = 36.66 C and the corresponding voltage is 367 mv.
99 F = 37.22 C and the corresponding voltage is 372 mv.
100 F = 37.78 C and the corresponding voltage is 378 mv.
101 F = 38.33 C and the corresponding voltage is 383 mv.
102 F = 38.39 C and the corresponding voltage is 384 mv.
103 F = 39.44 C and the corresponding voltage is 394 mv.
104 F = 40.00 C and the corresponding voltage is 400 mv.

With the experiment for temperature control, the measurements were done. Since, the differences between the corresponding mvs are very small, a non inverting amplifier can be used to gain the voltage. The gain, G= 1 + Rf/Ri and to get the gain 5, the value Rf=4 and Ri=1 can be set. Thus, the voltages gains after using the non inverting amplifier are:

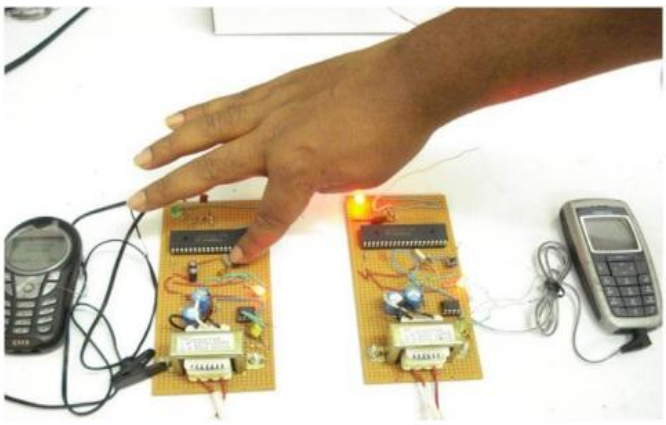

Fig -4: Remote control using cellular network [13].

For 98 F = 367 mv*5= 1835 mv=1.835 v.
99 F = 372 mv*5= 1860 mv=1.860 v.
100 F = 378 mv*5= 1890 mv=1.890 v.
101 F = 383 mv*5= 1915 mv=1.915 v.
102 F = 384 mv*5= 1920 mv=1.920 v.
103 F = 394 mv*5= 1970 mv= 1.970 v.
104 F = 400 mv*5= 2000 mv= 2.00 v.

After that, different frequencies for the different voltages would be set in microcontroller's program. As examples, 500 Hz is for 1.835 volt. 1.0 KHz is for 1.860 volt. 1.5 KHz is for 1.890 volt. 2.0 KHz is for 1.915 volt. 2.5 KHz is for 1.920 volt. 3.0 KHz is for 1.970 volt. 3.4 KHz is for 2.00 volt [13].

3. CONCLUSION

The change of temperature has been investigated using the optical frequency comb technology in many articles. Before the volcanic eruption, gas leaks from fumaroles. When gas leaks, the temperature would be increased thus refractive index would be changed. Therefore, as the refractive index is changed with temperature, the possibility of the volcanic eruption can be investigated by examining the changes of temperature of gas using this frequency comb technology.

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