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Development of Internet Based Instrumentation System for Real-Timevisual Monitoring of Volcano

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Abstract:- An instrumentation system for visual monitoring of volcano usually has a complex structure, this may make difficulties not only in device procurement but also in terms of maintenance. Building the system in simple structure and low budget is a challenge for researchers in the field of volcanology. Aim of this research is to develop a simple and efficient instrumentation system for real time visual monitoring of volcano based on internet network. In general, the system is built upon three main units, i.e.Sensing Unit (SU), Data Acquisition & Control Unit (DACU), and Network Interface Unit (NIU). The SUis visual sensor module, built using commercial CCTV camera and its electronic driver system. The DACU is control and data logger module, built based on PC's hardware and installed computer software that was developed for special purposes. The NIU is internet network interface (hardware and software), it allowing the users to access the volcano activity that was monitored by real time, from anywhere. We implemented a virtual machine techniques to reduce the hardware on DACU system in order to make it simple and low-cost in budget.

Keywords:- Data acquisition, Internet, Volcano monitoring, Virtual machine, Visual sensor

I. INTRODUCTION

Continuously monitoring of volcanoes activity is very important for at least two reasons. First is to monitor the level of volcano hazard relates to mitigation and management of natural disasters, and second is to understand the physical processes that occur inside the volcano, such as magma migration and the mechanisms that exist within the volcano[1].There are many methods have been utilized for monitoring the volcano activity. The efforts for establishing a good and reliable system for monitoring and predicting the volcano eruption is never ended. Instruments will never replace the expertise of the volcanologists in charge of the surveillance, but they definitely can help them in taking swift decisions in case of a crisis such as an eruption [2]-[3].

As we know, there are many parameters in volcano monitoring system; one of these is the visual monitoring. Visual inspections in volcano monitoring have been widely publicized, such as the mapping of activity as well as post-processing record results glowing lava [4]-[6]. In visual observation, the use of visual data capture techniques play an important role to get a good visual data without the need to await the time of the event. One of the challenges of visual inspection of volcano observation is that the change in the object that runs slowly. Object observation will produce the same visual data in a long time span. When emerging events, the data will be within the range of time that cannot be predicted. So the techniques to how ease to obtain the events data quickly and accurately without the need to examine all the results of observational data, it becomes very necessary.

On the other hand, advances in information and computer technology have successfully developed a method of virtual machine (VM) in many applications. Virtualization techniques allow multiple virtual servers running on a single physical machine (personal computer), and it has proven offer many solutions [7]-[9]. A VM is a software implementation of a computing environment in which an operating system (OS) or program can be installed and run. The VM typically emulates a physical computing environment, but requests for CPU, memory, hard disk, network and other hardware resources are managed by a virtualization layer which translates these requests to the underlying physical hardware. Software referred to as a "hypervisor" enables multiple virtual machines to run on a hardware host system [10]. Therefore, the implementation of the VM in the design of a data acquisition system will be able to reduce the use of hardware, thus reducing the cost of manufacture and the system will be much simpler.

An instrumentation system for volcano monitoring usually has a complex structure and expensive, this may make difficulties not only in device procurement but also in terms of maintenance. Building the system in the simple form and low-cost in budget is a challenge for researchers in the field of volcanology. In the previous research [11], authors have developed a simple instrumentation system for volcano monitoring especially for seismic activities, and the system has proven work well. However, the performance improvement is still needed to produce a better monitoring system. In this case, the capability of the data acquisition system i.e. the efficiency, access speed, and flexibility still needs to be improved. Aim of this research is to develop a simple, an efficient, and a low-cost instrumentation system, for online visual monitoring of volcano based on internet network by implementing VM technique. The system will be equipped with event detection procedures in order to classify the results of the visual monitoring automatically.

II. FUNCTIONAL BLOCK DIAGRAM AND DESCRIPTION OF THE SYSTEM

A. Hardware Structure

The basic structure of the instrumentation system that will be used for visual monitoring of the volcano can be seen in Figure 1. This structure refers to the basic structure of modern instrumentation systems that have been established [8]. While the details of the proposed instrumentation system for visual volcano monitoring can be seen in Figure 2. The system is built upon three main units, namely Sensing Unit (SU), Data Acquisition & Control Unit (DACU), and Network Interface Unit (NIU). The SU is visual sensor module, it is built using commercial CCTV camera and its electronic driver system. Output of this unit is a video image signal that can be controlled from DACU through a special computer program. The DACU is control and data logger, built based on PC's hardware and software that was developed for special purposes. In addition, we implemented virtual machine techniques to reduce the hardware on DACU system in order to make it simple and low-cost in budget. A VM-based DACU has the advantage to share resources on the PC's hardware to multiple virtual computers in accordance with their computing needs. Finally, the NIU is internet network interface (both hardware and software). The NIU will allow the users to access the volcano activity that was monitored by real time, from anywhere.

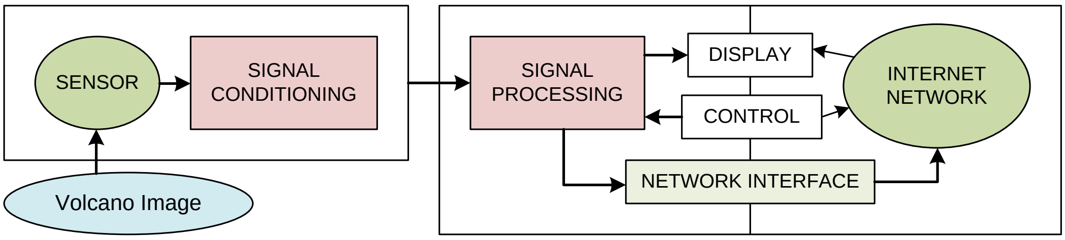

Fig.1: Basic structure of an instrumentation system

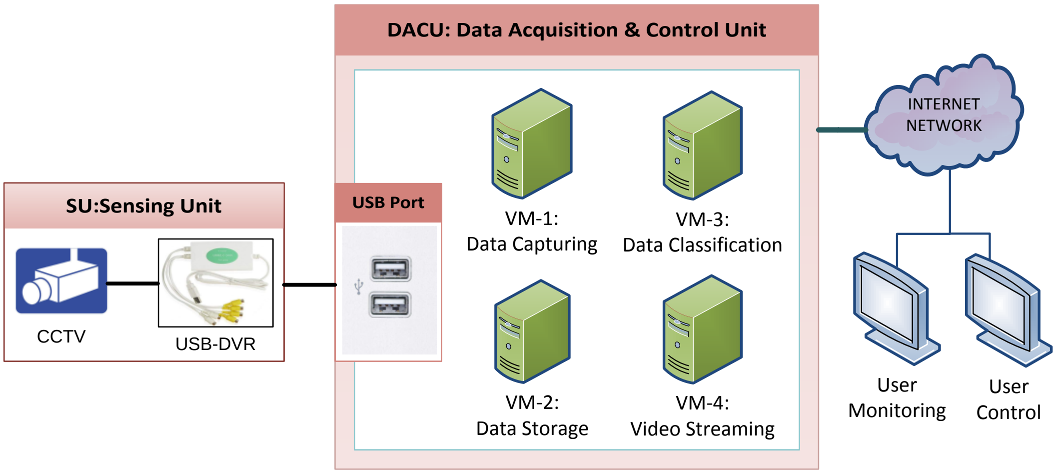

Fig.2: Functionalblock diagram of the developed system

B. Software Procedure

Retrieval techniques for visual image of the volcano is done by placing objects in the frame volcano camera based on the photography principles of Rule of Thirds [12]. In this role, an object placed in the camera frame that meets 2/3 or 1/3 portion of the overall frame. It is intended that the main object of the volcano to be the main focus of the frame to get a panoramic picture object, centrally. Furthermore, all observational data are recorded and detected changes (i.e. changes in the visual image of the volcano) with motion detection methods. By this method, the visual changes to the object can be detected specifically in a particular area. Data results from event detection are then stored on the Internet-based storage media, that can be accessed by users via the Internet. Thus the visual monitoring of the volcano with event detection facilities, can be done online and all the time. Figure 3 illustrates the flow diagram of visual monitoring performed, starting from the data acquisition, storage, record the results, sending video data post-processing with motion detection and event notification presence.

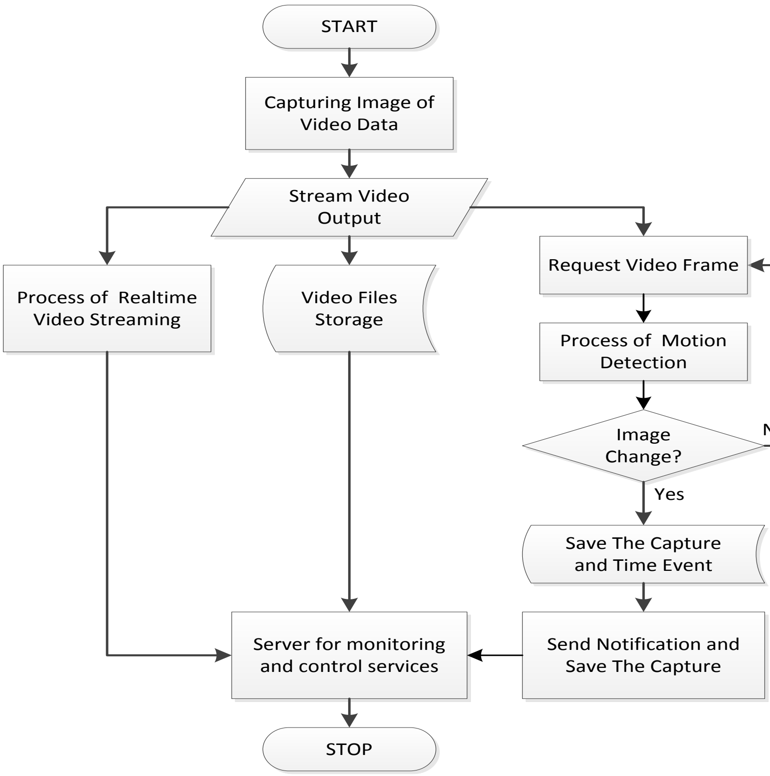

Fig.3: Flowchart of the visual monitoring system

III. SYSTEM DESIGN AND IMPLEMENTATION

A. Hardware of the System

Instrumentation system offered in this study built both in hardware and software. The hardware system consist of CCTV cameras and its electronic systems (i.e. Signal conditioning and control device), and a standard PC used as a server. Figure 4show thehardware of the system, and details about the specifications of the hardware are as follows:

- Visual Camera: Surveylance CCTV CCD with 22x Optical Zoom feature IR Cut-Off Filter.
- Signal Conditioning & USB interface: USB-DVR Easycap DC60 Somagic SMI.
- Control Device for Camera, with zoom and focus control.
- Personal Computer (PC)-CPU: Intel Dual Core 2x2.5 GHz, 6 GB memory and 1 TB hard disk.

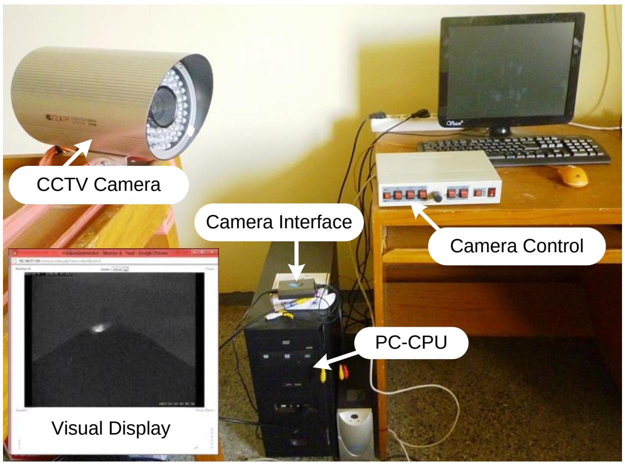

Fig.4: Hardware of the system

B. Design of VM-Based Data Acquisition & Control Unit (DACU)

The DACU is built by the use of standard PC, which also functioned as a server. It then divided into several VM, namely VM-1, VM-2, VM-3, and VM-4 by using hypervisor software i.e. VMware vSphere ESXi. Each of the VM assigned to conduct special task (see Figure 5).Human Machine Interface (HMI) is the software that serves to provide access for monitoring and control to the user. HMI software developed using the VMware vSphere Client. Access control on the DACU set using user permissions by entering user name and password.

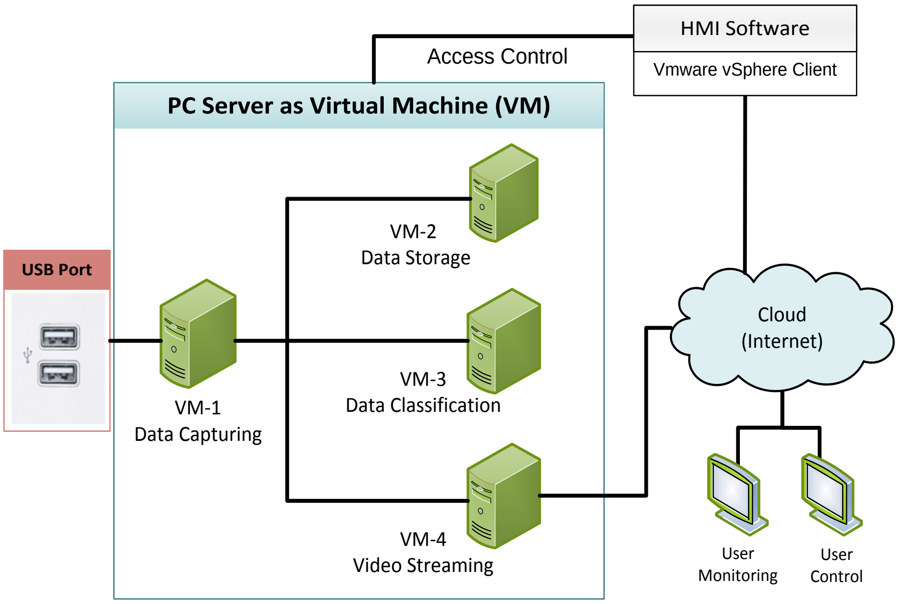

Fig.5: The division of PC Server into several VMs

Functional description of each VM can be explained as follows. The task of the VM-1 (Data Capturing) is capturing the video data transmitted by the SU through the USB interface, and forward it to three other VM. A video data typically has fast flow, so that VM-1 requires adequate computer memory and processor resources, so the resource allocation for the VM-1 should be prioritized, it aims to avoid the data loss due to insufficient resources. VM-2 (Data Storage) served as data storage of all of the recorded video data by the VM-1, without going through the editing process or the other. In addition, to serve access of users who want to see the video data records. Further, VM-3 (Data Classification) has fuction to support the event detection system. This is an implementation of the method of Motion Range Event Detection, that can be used as a event detection on the volcano object. It provides output from the report the change of events at a given time, and also record the time of the incident simultaneously. VM-4 (Video Streaming) serves as an Internet access service on the results of monitoring, so that the user can observe the results of visual record of volcano object in realtime. In ordr to increase resource usage does not interfere with the performance of other VMs, the use of VM-4 to serve video streaming only is needed.

Table 1 illustrates the distribution of the parameters of the needs of each VM on the developed visual monitoring system. The division is intended that each VM can work optimally according to function, and the high load on one VM will not affect the other VMs.

Table I: Parameter Resource Requirements for Each VM

VM Name	Function	Priority Resource	Special Devices
Data Capturing	Reading Data from Sensor Interface	Processor	USB- Interface, TCP/IP Connection
Data Storage	Storing Video Data	Hardisk	TCP/IP Connection
Data Classification	Analyzing the results of monitoring video	Processor & Memory	TCP/IP Connection
Video Streaming	Serving User Access	Processor & Memory	TCP/IP Connection

C. Event Detection of the Volcanic Object

The process of taking pictures of the volcano based on how to determine the best of the "Field of View" (FOV) of the volcano object to changes that may occur. Volcano is defined as a static object, it means that at an early stage in the camera frame is set as fixed object and does not shift in position. So if there are changes in the FOV frame specified, it will be detected as a volcanic event. After determining the POV frame, then performed the Sensing Area Definitive (SAD). The SAD associated with motion detection system that will be imposed on the results captured from the FOV frame. This step is useful for filtering the object to be detected specifically. For example, location of lava flows and pyroclastic can be predicted in the area of the FOV frame, so the motion detection system does not need to check all of frames. Then it is important to pay attention to the visual identification of the volcano object, since it is possible that many objects can move into the FOV frame that can caused a false notification, such as flying animals, trees exposed to wind and rock slides.

The physical parameters were observed in the visual monitoring of the volcano are generally pyroclastic flows or lava flows caused by volcanic eruptions. This physical phenomenon, typically occurs in certain areas of the volcano can be predicted in advance. Table 2 describes the placement of main object the volcanic in FOV of camera.Placement the FOV is a key role to identify the volcano were observed, so that it can produce a good data record to be implemented on the post-processing work.

Table II: Identification of the Environment to be Used in the Placement of FOV of the Volcanoes

Parameters	Location Source	Direction Movement Prediction	Frame FOV Placement
Pyroclastic Flows	Crater	Up	1/3 part of Center-Top
Lava Flows	Crater	Down	2/3 part of Center-Bottom
Lava Flows	Crater	Right-Down	2/3 part of Left-Bottom
Lava Flows	Crater	Left-Down	2/3 part of Right-Bottom

IV. RESULT AND DISCUSSION

The results of implementation the VM-based DACU is as shown in Table 3. The table shown the distribution of each VM that serves a process which has been determined according to the VM name and function of each. Naming VM adapted to a given function, serves as the computer's host name identification to facilitate the management process. Each VM is run by different operating systems according to the needs of each function. So that VM performance can be further optimized in accordance with computing functions to be executed. Figure 6 shows the control interface to each VM on DACU.

Table III: Distribution of VM onPC Server (DACU)

VM-Name	Computer Host	Function	Operating System
VM-1	akusisi.video.geomonitoring	Reading Data from Sensor Interface	Windows XP SP3
VM-2	storage.video.geomonitoring	Storing Video Data	Unix FreeBSD Freenas
VM-3	motion.video.geomonitoring	Analyzing the results of monitoring video	Linux Ubuntu 12.04
VM-4	web.video.geomonitoring	Serving User Access	Linux Ubuntu 12.04

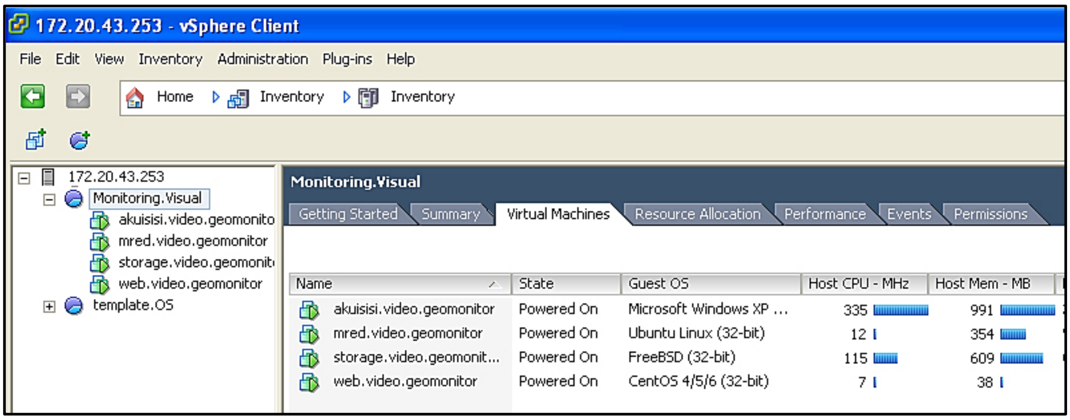

Fig.6: Control interface for each VM on the DACU

The advantages of the implementation of the VM on the development of a data acquisition system (DACU) lies in the fulfillment computing processes on the system. If there are additional sensors on the SU, then the conventional DACU have to make adjustments to the device and data communication lines first, this does not happen on VM-based DACU. The use of interface hardware and data communication between the SU-DACU performed through a standard interface that has been owned by the computer (USB). Therefore, the fulfillment of the SU services on a VM-based DACU can be more efficient because it can accommodate multiple processes together, even for processes that require fast data transfer and continue running simultaneously without interruption.

At the Human Machine Interface (HMI), VM-based DACU do control carried over long distances via the internet network, by using the HMI software that are accessed from another computer. In the process DACU control, the kind of control that can be done include making a new VM, regulate the distribution and use of resources VM, store and install a new operating system, automation of work at SU, and so on.

Data monitoring results in the form of video files, stored in the storage network. Network Attached Storage (NAS) is a method of storage system that can be accessed through the Internet. A NAS server is useful to run a data storage that can be accessed from the network. Physically, the data remains in the hardisk, but functionally in virtual form. In Figure 7 is shown the display of the video capture that accessible from the drive which is connected through the internet network.

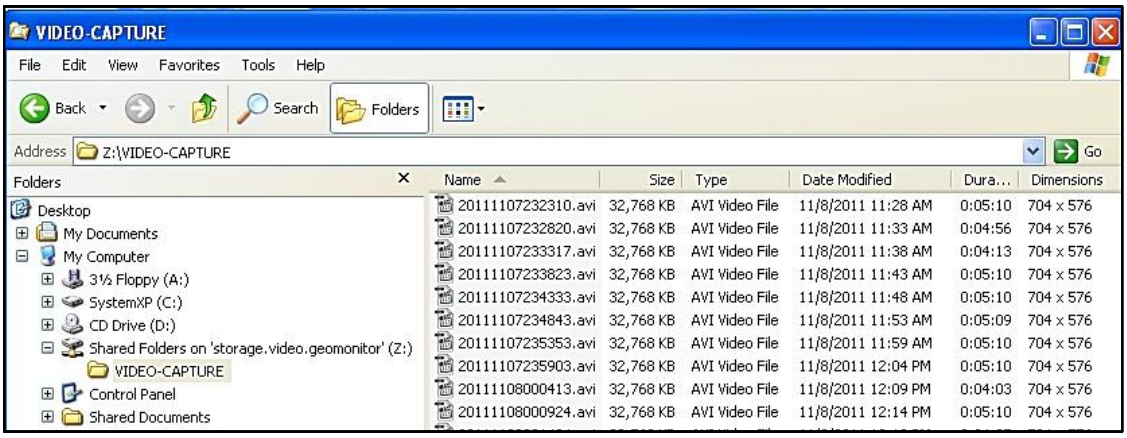

Fig.7: Video-datarecord that can be accessed via the internet

Event detection systems in volcanic activity carried out by a change in volcanic eruptions is visually recorded by a video camera. The algorithm used is the frame differences. This algorithm is part of a motion detection application that calculated using SAD.Event detection systems on volcanic activity carried out by using a change in volcanic eruptions is visually recorded by a video camera. The algorithm used is the method of frame differences that set point pixel comparison technique for two types of images simultaneously. This algorithm is part of a motion detection application applied through methods SAD as shown in Figure 8.

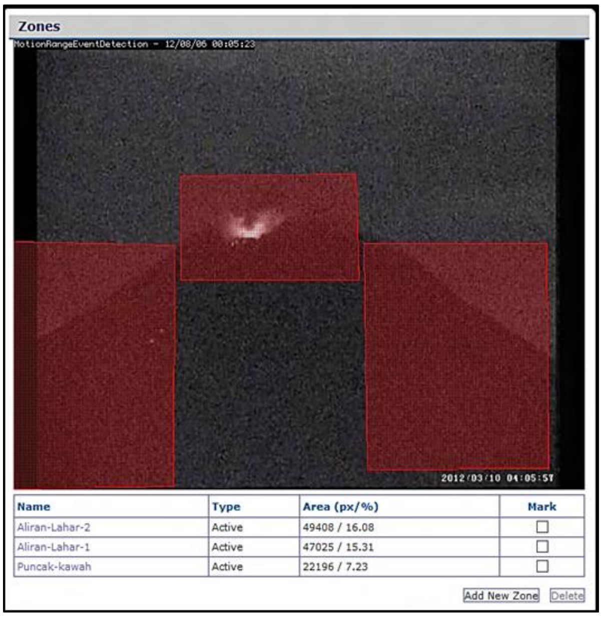

Fig.8: The SADprocessfor Motion RangeEventDetection.

Figure 9 shows how the visual results of the monitoring process carried out through a connection between DACU to users via the Internet. Visual monitoring of the user can be done from any location connected via the Internet.Results of video capture can be accessed with the quality of the average frame rate of 10 fps to 15 fps. With a video resolution of 640x480 pixels (and can be digitally zoomed up to 3x), the volcano object can be seen clearly. So the visual monitoring system can provide qualitative information to the user either directly through video streaming or event detection.Furthermore, it should be presented herethat theinterpretation ofthe observationsdatais not themain goal in this research. The researchisfocused onthe development ofvisualinstrumentationsystemthat can be accessedby usersvia theinternetnetwork in real time;store the results ofthemonitoringand detecting thepresence ofspecificEventtobe observed.

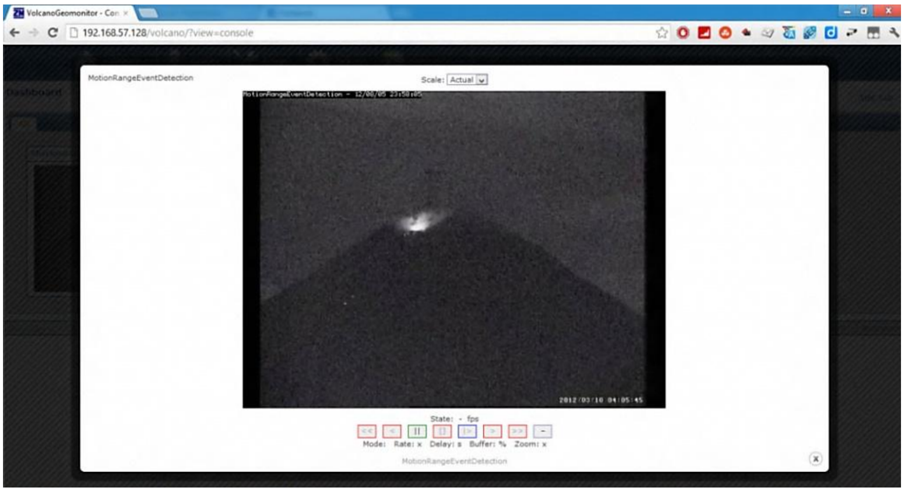

Fig.9: Online monitoringof the volcano via internet

V. CONCLUSIONS

Aim of this research is to develop the simple and efficient instrumentation system for real time visual-monitoring of the volcano. The system is built upon three main units, namely Sensing Unit (SU), Data Acquisition & Control Unit (DACU), and Network Interface Unit (NIU). The SU is visual sensor module, it is built using commercial CCTV camera and its electronic driver system. The DACU is control and data logger, built based on PC's hardware and software that developed for special purposes. We implemented VM techniques to reduce the hardware on DACU system in order to make it simple and low-cost. The NIU is internet network interface,it will allow the users to access the volcano activity that was monitored by real time, from anywhere.The system equipped with event detection procedures in order to classify the results of the visual monitoring automatically. This system has been implemented and tested for visual monitoring of volcano object and proven work well.

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