SMART CLASSROOM: A WHITEBOARD VIDEO CAPTURING APPLICATION

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Abstract As wireless sensor networks become widely used and they both evolve in computational power and decrease in size, there are multiple domains that can benefit from the use of sensor network structures. An application domain is the educational classroom environment. Sensor network technology approaches can enhance and enrich the classroom experience and the educational procedure. In this paper, we have present a prototype platform for whiteboard video capturing during a lecture session, describing both the hardware deployed and software developed to serve the application needs.

1. Introduction

As wireless sensor technology becomes more popular, there is increasing interest in deploying infrastructure that helps the educational procedure evolve. The idea presented in this paper is to capture the white-board notes in a video during a lecture based on the use of a sensor board, a camera, a classroom PC and a web and mailing list server. When a lecturer uses the marker to write on the board, the markers motion is detected and a video recording procedure starts. When that activity stops, the video recording pauses and an e-mail notification is sent to a lists subscribed users containing the URL where they can download the lectures video.

The idea of using interactive whiteboard in classroom, has risen the need for the development of techologically improved whiteboards to support new educational paradigms. Many related prototypes and marketed products have been introduced, developed either in industry or academia. Technologies used are:

- touch-sensitive, based on touch between two slightly seperated conductive sheets. Marker is located by establishing the (x,y) location of the contact.
- electromagnetic, an uniform array of wires under the board surface interacts with a coil in the marker in order to determine (x,y) coordinates of the marker.
- laser, a laser beam scanns the whiteboard surface and locates the markers position using triangulation methods.
- ultrasonic and infrared, with the use of infrared and ultrasonic signals and similar methodology as in laser implementation, markers position is located.

2. System Model

A board having an accelerator is bundled on the marker and transmits the sampled data of the two dimension values of acceleration using an RF transmitter. A RF receiver, connected to the PC, receives the acceleration data and stores them in a MySQL database. A software installed on the PC retrieves the acceleration values from the database and applies a Motion Detection (MD) algorithm. The MD distinguishes between the two states of activity or idleness of the marker. When activity is detected, a camera that is focused on the whiteboard is switched on captures the video of the activity. Then, the whiteboard capturing software uploads the captured video to the server and informs the subscribed users of the list of the new video upload. The web server based on Apache provides a simple web interface so the interested users can subscribe to receive the email notifications.

3. Implementation Details

Before we go into the details of our implementation and experiments, it is important to list the assumptions made for this version of our implementation. The assumptions are as follows:

- It is important to distinguish real activity on board with a potential movement that comes from environmental noise or irrelevant marker motion. The MD algorithm is configured appropriately to overcome that limitation by an input filtering scheme.
- A web service for mailing and video storage is always available to the subscribed users.

3.1 Hardware and Software

The mica2 board having the MDA310 accelerometer is bundled on a marker. Another mica2 mote acting as the sensors board receiver is connected via serial to the PC. The software implementation was developed using the Java programming language. The Java Media Framework and the Java Mail API were used for the camera control and the notification mailing service. A web server based on Apache was used for hosting the web interface, video storage and the GNU Mailman software for the mailing list service.

3.2 Motion Detection Algorithm Description

Before we proceed in the MD algorithms detailed description, it is useful to explain the rationale behind algorithms implementation in a high level manner. We use appropriate signal metrics and a time window filtering technique to detect the need for video capturing. The received signal of time slotted acceleration values converge to a mean value. That allows us to take an accurate decision on motion detection by observing the fluctuations of this signal against the mean value in a specific time window.

The algorithm is using a discrete time system having the accelerometer sample rate as the finest time slot granularity. In a time slot, one read from the RF receiver strictly occurs. We define S as the received signal. S is a function of time. S_{avg} is the expected average mean of signal S. Assume λ is an indicator function to capture motion activity of S and it is defined by the following equation: $\lambda\left(t+1\right) = \lambda\left(t\right) + Q|S\left(t\right) - S_{avg}\left(t\right)|$, where Q is a positive scaling factor with a small value close to zero in order to smoothen out the function values. Function λ reflects for a specific time slot t the scaled change of signal S on the mean value over time S_{avg}.

Camera on denotes the state of camera where 1 stands for when the camera is turned on, 0 otherwise. Sensitivity characterizes the systems response effectiveness in changing states, from activity to idleness and vice versa. ws is a time window size, tw is a $1 \times ws$ vector to store the ws previous time values of function λ and mt is a $1 \times ws$ vector to store the mean value of window tw in a time slot. This filtering occurs to avoid an irrelevant possibly abrupt marker movement. Indeed, modifying the sensitivity, epsilon and ws values, adjusts system functionality in respect of video capturing detection. After exhaustive experimenting, the aforementioned values chosen were the most fit for our whiteboard video capturing application. It is essential to mention that MD algorithm takes a decision for motion detection at run time.

4. Experiments

We demonstrate an example of motion detection in a received signal. In this experiment, we set sensitivity to 2.5, $ws = 250$ and $Q = 0.001$. Function λ shows a pulse for a detected motion. The points enclosed in black circles show the start of a motion activity and the red ones denote the end, respectively. Those points are mapped to the initial signal S so as the motion is detected correctly.

5. Conclusion and Future Work

In this paper, we discuss implementation issues of a smart class using sensors. Use of sensors in educational environments can help the educational procedure evolve. Indeed, students and lecturers have a fine opportunity, to seek notes in past lectures removing the need to copy whiteboards contents and concentrate on lectures concepts and ideas presented. As far future work is concerned, we are further developing the server side part of the service to concatenate videos belonging to the same lecture and organize better the server database backend to store video recording per lecture and class. The users would be able subsequently to query the database and retrieve past notes in an easy and burden less way.