Centralized Ubiquitous Video Monitoring

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Abstract

Ubiquitous video camera and other monitoring system equipments can be installed anywhere in a real environment. Video cameras are acquiring data from the real world without (necessary) user perception of the presence of ubiquitous devices. In help of the ubiquitous video technology two remote persons can establish eye contact and start conversation with each other. There are also growing public interests to transfer from traditional monitoring systems toward the “ubiquitous information society” and thus increase and create safer and more secure society. Also new business opportunities are created constantly to different monitoring coverage areas e.g. sport arenas, school-commuting routes, hospitals, public transport and station premises.

Keywords: Ubiquitous video, monitoring, mobile cameras, virtual environment, real-time access.

1 Introduction

Ubiquitous computing is often described as computers fading into woodwork. Ubiquitous video is described in similar way, now cameras are fading into woodwork. It can be characterized by wireless networked video cameras located in every conceivable environment. Depending from the target user audience and data security level classification, data is transmitted either to the central server for further processing or simply into the public Internet or network for all users to view [1].

The needs of the outdoor video monitoring services are increasing dynamically, for example in public parking areas and school routes. Traditional monitoring systems are demanding a lot of construction costs because of missing or upgrading network infrastructures. Ubiquitous ad-hoc monitoring system is effective for these situations [3].

2 System configuration

Ubiquitous monitoring system components can be divided to three separate categories. Information acquisition units or sensors like video or thermal cameras, infrared sensors.

2.1 Planning the system

Issues to be resolved before making (any) video monitoring system.

1) Low cost for construction
2) High reliability
3) Easy to set up and use

In ubiquitous systems first and third issues are solved easily with no need of wiring work, low-cost devices and short network construction period. Also ad-hoc network is self-configurable and it's easily expanded, ensuring high-quality of communication [2].

2.2 Sensor functionality

Each sensor unit monitors it's own preliminary set surveillance area in real-time. Stereo vision technique may be used to speed-up rate of the object detections. A detection processor of the camera sensor can recognize moving and stationary object detection, object recognition and object tracking through several detection processes. Multiple and simultaneous sensor detections can provide high reliable results.

2.3 Exploring in physical space

Ubiquitous video system can offer solution for requirement where user request to do remote exploration within camera coverage. System requirements for supporting this
functionality are abstraction of infinite camera coverage, scalability and robustness to changing user requirements. Abstraction of infinite camera coverage can be created by using number of cameras which can monitor physical area. Cameras are producing live video data and still images. When video data streams from each camera are edited by centralized processing unit, user can utilize the processed data and explore in the camera coverage space. System is scalable and expandable by adding cameras and sensors.

Free exploring concept is known as tele-reality. It is explained by a model for analyzing images from multiple cameras and developing photo-realistic novel views from locations which are not in camera coverage. In ubiquitous system, aim is to combine multiple video data streams by centralized processing unit to more complete view of the environment.

Humans has natural ability to make sense of incomplete information, which aids to perform transition and moving from video frame to another effortlessly. Human visual cortex is able to smoothly interface inaccurate images to more accurate and clear video information. For other words, human brain has capability to fill in gaps when given incomplete information.

The main limitation of ubiquitous video is the incomplete availability of the live video streams. Every square meter of a space and can not be viewed at any chosen moment of time. To reduce this minus effect, older video data can be used for free viewing of space instead.

Still image overlapping technique can be utilized when live video data is not available. Some additional information (sepia tone, time stamp or age-indicator bar can be displayed) for the security applications where older images are harmful [1].

2.4 User experience of remote exploration

In the current technology, maximum transition time between the images is no more than one second. Transitional frames should not be used disconnected or loose, part of the frames should be interpolated to live video data. "Hitchhiking" term is used when live video data is showed without centralized video processing. Experience is like watching own home-video where camera person is walking around the space. If only still-images are available, experience is like watching paused or jumping video, depending the spatial space of the picture frames.

To simplify original and real 3D space, virtual simplification (virtual walls) is to fill entire screen with 2D space. Near objects are pushed out on the image surface and distant objects are pulled in to the image surface. Additional images can be displayed (if frames are available and user is requested to get more accurate information) to be able provide more contextual information.

Results in the field tests have proven that 6-9 meters accuracy is enough for outdoors. Since human visual cortex can fill gaps and find correlations between frames, there should be at least close enough images (images are then overlapping each other). Higher accuracy is needed indoors. Also typical web camera has 40 degree field of view and view can’t be off by many degrees until images do not overlap anymore [1].

2.4 Video conferencing

Video conference connection can be created between two remote ubiquitous computing environments and conversant can establish eye contacts together. By object tracking eye contact can be maintained also if person moves inside their ubiquitous camera sensor locations.

To achieve this, several technologies are exploited. Perspective manipulation of the imagery, head tracking by computer vision and pinhole video cameras embedded inside of walls.

The displacement angle ($\theta$) must be minimized or completely eliminated to be able perform eye contact. There are several ways to do it. First approach is manipulate the video so it seems to be captured from eye level and in front of looker’s eyes. This can create unnatural faces and force to eye contact when not suitable. Second approach is to merge optical path of the camera and the display. This requires fixed positions in front of the display. Third approach is to fix camera close to the display. This is effective in small PDA displays but not suitable for any bigger displays. Fourth option is introduced in table 1. This option is combination of positive options from all three approaches:

<table>
<thead>
<tr>
<th>Property taken</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>From approach 1</td>
<td>Manipulating the video with object tracking</td>
</tr>
<tr>
<td>From approach 2</td>
<td>Camera is always positioned in the display</td>
</tr>
<tr>
<td>From approach 3</td>
<td>Optical path of looker’s and observer’s eyes are closely aligned</td>
</tr>
</tbody>
</table>

Video cameras are installed to video conferencing participant premises. Both environments have projector displaying image in to wall. System uses face-finding algorithm to detect where person is currently and changes to the other camera if person is moving [4].

![Figure 1. Concept of video conferencing anywhere. Ubiquitous sensors are embedded to walls and cabinets. Dots in walls are presenting ubiquitous video cameras. Black rectangles are presenting projectors which can display face of the opponent to the eye level of the](image-url)
standing or sitting person.

2.5 Object detection and recognition

Passenger monitoring system with ubiquitous detection sensors can be used to improve public transportation safety. Restricted and dangerous areas for passengers can be defined and observed with monitoring cameras. Sensors can detect dangerous situations like person moving or falling in railway platform or disastrous fire.

Vehicle states for each camera sensor units can be seen from table 2. The object detection and recognition is carried out mainly during OFF state because object detection is most important in OFF states.

**Table 2. Vehicle states for camera sensors**

<table>
<thead>
<tr>
<th>Vehicle states</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>There is no vehicle in the monitoring area</td>
</tr>
<tr>
<td>IN</td>
<td>Vehicle is approaching</td>
</tr>
<tr>
<td>ON</td>
<td>Vehicle is stopped (in the monitoring area)</td>
</tr>
<tr>
<td>OUT</td>
<td>Vehicle is moving out of the monitoring area</td>
</tr>
</tbody>
</table>

Vehicle states can be defined by four states machine. Moving from state to state can be defined as shown in table 3. In addition, state can also return to itself. Movement of a vehicle can be used to make decision to move from state to another state. More than five continuous picture frames are analyzed for removing the noise effect interferences.

**Table 3. Four states of vehicles**

<table>
<thead>
<tr>
<th>Current state</th>
<th>Next state</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>IN</td>
</tr>
<tr>
<td>IN</td>
<td>ON</td>
</tr>
<tr>
<td>ON</td>
<td>OUT</td>
</tr>
<tr>
<td>OUT</td>
<td>OFF</td>
</tr>
</tbody>
</table>

When object movement is detected in the controlled area, monitoring system can determine in which direction object is coming from and make conclusions is object completely in dangerous area and is object human or not. When moving objects are entered to controlled are, those can be identified by green rectangular lines. If object is entirely on dangerous area, it is identified by red rectangular lines. System is tested and can identify different conditions like news paper, dolls and real humans [2].

2.8 Conclusions

Ubiquitous video monitoring systems have many use purposes in modern society to improve security and public safety. Video monitoring with heat and fire detection sensors are started to test and taken to use in most advanced systems and countries in front line of the information technology.

Video conference system with ubiquitous monitoring sensors can mentioned to near future choice of communication to homes and offices.

Gaming industry could start develop applications and game ideas based on ubiquitous video technologies. Concepts of tele-reality and virtual reality will start to come closer and closer of each other. Tele-immersion is ideal virtual reality experience.

Person tracking can be created with the combination of ad-hoc network technologies and ubiquitous video monitoring system. System can share real-time information in the field of mobile terminal. One clear application area is watching and securing children trips along the school routes, offering also location services. System can give confirmation to parents of going or leaving to school and alert by broadcasting a warning message to police, school and parents [3].

There are dangers and not ready answered problems when using information sharing techniques like “hot-potato” where data is transferred from chip to chip. Personal information becomes scattered over a wide area. Usually when security is strengthened, usability fails. Matters yet to be considered, further developed and solved are issues like illegitimate-user tracking, prevention of illegitimate-use and information leakage, privacy and copyright protections and anonymous services [5].

References


