Intelligent Vision System for Dynamic Environments

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Abstract

This paper describes an intelligent vision system that absorbs useful information from its environment and draws useful conclusions. This system can give the instructions to locate vacant seats that are currently occupying in a cinema theater. Extraction of useful information without viewing or exposing inside details of an environment through an active vision system is proposed. Reasoning based conclusions are drawn for optimum searching. The effectiveness of the proposed method is demonstrated using an experiment.

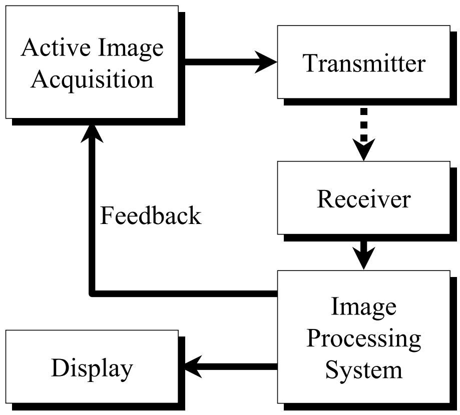

Figure 1: Intelligent vision system architecture

1 Introduction

Computer vision is a new and rapidly growing field, currently focusing on building intelligent systems. It basically processes active image data captured by a vision system and draws intelligent conclusions. Much accurate timely information could be obtained without human involvements. In practice, this would also save time, avoid the occurrence of any disturbances and enhance the security. As an example, in a multi storey building, required information of a particular floor that is used for common seating could be displayed at other floors (see **Fig. 1**). In a parking, registration numbers and the entering time of the vehicles could be recorded. Camera system would be used to obtain a view of that particular environment and the desired data is transmitted to the location where the data is processed in order to display the useful information. Finally, all these disciplines are needed for building advanced intelligent systems [1].

Image processing plays a great role in this research field [2] backed by artificial intelligent techniques [3] in order to build these intelligent vision systems. Combining visual model acquisition and agent control system was presented for visual space robot task specification, planning and control [4]. In [5], an evolutionary based approach was described to develop an active vision system for dynamic feature selection with simple neural control system.

In the present example, the system first detects objects or humans on the seats using a wide-angle image and analyzes them for conclusions. Image data is continuously transmitting from the environment and analyzing for vacant seats using image-processing techniques. Reasoning based conclusions are drawn for the users entering into the environment for optimum seat searching. The recognition algorithm with image processing tools will be used in order to analyze video images. The experimental results show the feasibility of the system. The rest of the paper is organized as follows: system features and methodology are described in Section 2 and Section 3, respectively. In Section 4, analysis used for identification is presented. Then, some experimental results are given in Section 5. Finally, concluding remarks is given in Section 6.

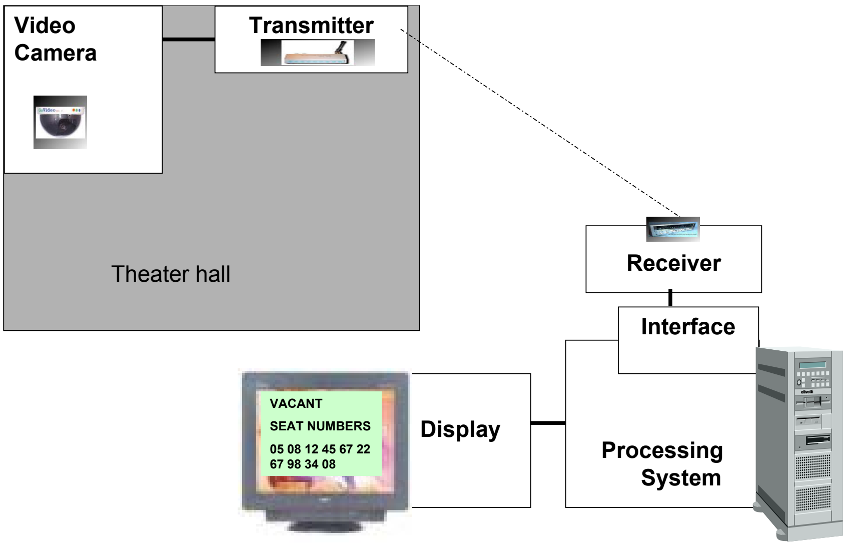

Figure 2: System architecture for the experiment

2 System Overview

In this illustration, we use a cinema theater hall, which should be arranged in such a way that a clearly distinguishable mark should be stick on each chair and seat locations should be unchanged after setting up the system. Once the system is set up, seat locations should be unchanged and if seat locations are going to be changed the system should be set up again before using the system. If it is going to change, simple recognition mechanism can be employed in order to apply this technique. The video camera should be fixed at a correct elevation to get the plan view of the theater hall. Install and configure the transmitter receiver camera system. Focus the camera, adjust the position and correct the lighting level if required by previewing the video stream. Basically, the system used for the experiment is similar to the system in **Fig. 2**. Follow the set of instructions that comes with image acquisition device. Setup typically involves:

- Installing the frame grabber board in your computer.
- Installing any software drivers required by the device.
- Connecting a camera to a connector on the frame grabber board.
- Verifying that the camera is working properly by running the application software that came with the camera and viewing a live video stream

The device ID is a number that the adaptor assigns to uniquely identify each image acquisition device with which it can communicate. The video format specifies the image resolution (width and height) and other aspects of the video stream. However, before starting, you might want to see a preview of the video stream to make sure that the image is satisfactory. For example, you might want to change the position of the camera, change the lighting, correct the focus, or make some other change to your image acquisition setup.

3 Methodology

We develop this algorithm to setup the system explained in Section 2:

1. Read the color image frame acquired from image acquisition device.

2. Convert color image to an intensity image.
3. Resize intensity image so that the image matrix could be viewed.
4. Suppress light structures connected to image border
5. Convert clear border image to a binary image
6. Create sub matrices M_i and $\hat{M}_i$ (explained later in Section 4)
7. Process and determine whether the seats are vacant or not
8. Display the results

Note here that once the system is set up, seat locations should be unchanged and if seat locations are going to be changed, the system should be set up again before using the system.

4 Image Analysis

The video camera should be fixed at a correct elevation to get the plan view of the theater hall. Install and configure the transmitter receiver camera system. Focus the camera, adjust the position and correct the lighting level if required by previewing the video stream. When nobody is seated in the hall, a color image frame is acquired and converted to an intensity image and then processed in order to set up the system as below. Consider intensity image matrix $f(x, y)$ of dimension $m \times n$

$$f = \begin{bmatrix} f(0,0) & f(0,1) & \dots & f(0,n-1) \\ f(1,0) & f(1,1) & \dots & f(1,n-1) \\ & & \vdots & \\ f(m-1,0) & f(m-1,1) & \dots & f(m-1,n-1) \end{bmatrix}$$

Here $f(x, y)$ was subjected to reduce overall intensity level and to suppress structures that are lighter than their surroundings and that are connected to the image border and converted to a binary matrix A.

Next, consider matrix M_i such that

$$\begin{aligned} M_i &\subset A \\ M_i &\subset \hat{M}_i, \end{aligned}$$

where $i = 1, 2, ..., S$. Here, i is the seat number and S is the total number of seats detected by the camera.

Sub matrix $\hat{M}_i$ should be selected from matrix A such that its center element or elements should align with the center element relevant to the mark on seat i. Dimension of $\hat{M}_i$ should be as large as possible subjected to the criteria that all the elements should cover the mark area and some more space beyond the mark too.

Then the matrix $\hat{M}_i$ should be selected in a way that $M_i \subset \hat{M}_i$ and dimensions of $\hat{M}_i$ should be $(m + p) \times (n + p)$, where p is an integer. Center element of M_i and $\hat{M}_i$ should be aligned with each other.

Then use the following criteria to determine whether the seat is vacant or not

$$\begin{aligned} &\text{IF } \sum_{j=1}^{m}\sum_{k=1}^{n} m_{jk} = mn \\ &\text{AND } \sum_{j=1}^{m+p}\sum_{k=1}^{n+p} \hat{M}_{ij} \neq (n+p)(m+p) \\ &\text{THEN Seat is Vacant} \end{aligned} \quad (1)$$

5 Results

Figure 3 shows the resulting images according to the algorithm explained in the previous sections. Use of three marks on the seat instead of one mark enhanced the reliability. As shown in **Fig. 4(a)** when the seat is occupied by a person all three marks will be covered and when there is an object placed on the chair such as a bag may not cover all three marks. Use of remarkable color mark with a fine thick edge as shown in **Fig. 4(b)** and suitable lighting conditions enhanced the system.

6 Conclusions

The system has detected objects or humans on the seats using a wide-angle image and analyzed them for conclusions. Image data was continuously transmitting from the environment and analyzing for vacant seats using image-processing techniques. The reasoning based conclusions were drawn for the users entering into the environment for optimum seat searching

The system can be further developed and generalized for other applications. In a multi storey building,

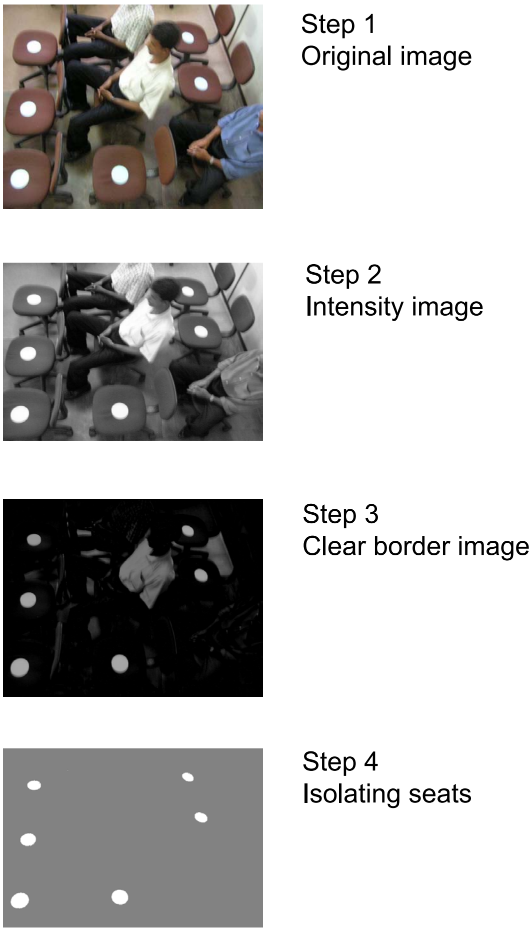

Figure 3: Image processing steps

required information of a particular floor that is used for common seating could be displayed at other floors. In a vehicle park, the registration number and the entering time of the vehicles could be recorded.

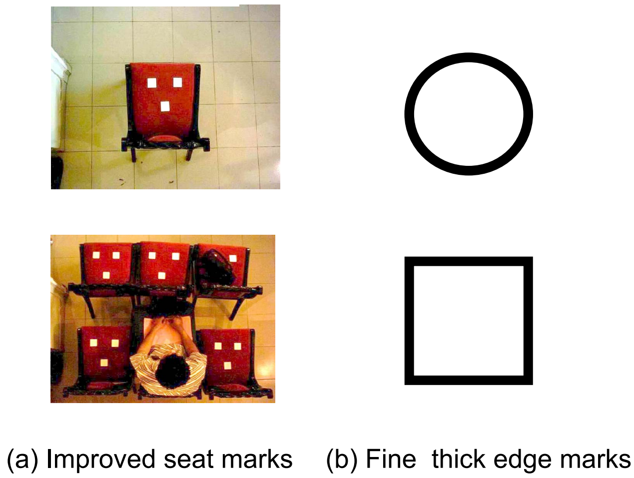

Figure 4: Improving the accuracy

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