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Soccer". Lecture Notes in Computer Science, 2006**paper text:**

Abstract Introduction Keywords Feature-based Method, Appearance-based Method, Genetic Algorithm, Fuzzy Clustering, Machine Vision, Statistical, Spectral, Model-based Method, Image Stabilization, Head Pose, Gaze Determination, SIFT (Scale-Invariant Feature Transform), Motion Estimation, Motion Compensation, Filters, AdaBoost, Haar-like structure, Segmentation, Thresholding, Texture, Histogram, Spectroscopy, Hyperspectral. 1. Industrial Applications INDUSTRIAL APPLICATIONS AUTOMOBILE INDUSTRY FOOD AND BEVERAGE INDUSTRY FABRIC INDUSTRY - Detection of gaps - Detection of fasteners - Classifying empty bottles for recycling - Quality grading of fruits - Identifying defects in texture and color Fig.1 Topics discussed under Industrial Applications Real-time object recognition is made use of in industrial applications. This mainly recognizing 3D objects. Object recognition is important here as the manufacturing process in most industries is automated. As industries grow they have to cater to larger demands. Consequently, industries increase their production. Increased production in turn results in chances of making errors. In any mass manufacturing industry, as the production scales are enormous, it is nearly impossible to implement a manual quality control. This is why object recognition has been gaining importance in industries. 3D object recognition is used to implement quality control. For humans, recognizing and classifying objects is a trivial task. When it comes to computational object recognition, it is much more complicated. Objects often have to be recognized under varying illuminations, from different angles or may be undergone some deformations. Another constrain, is the involvement of complicated mathematical problems like relationship between different geometric shapes and the projection into 2D images. Good object recognition also relies on the diversity of the training images (Thomas (1995)). 1.1 Automobile Industry In the automobile industry, quality cannot be compromised. Therefore supervision at different stages in the production is absolutely essential. The main constrain here is that similar defects can be present at different stages of the production, but the defects have to be identified without fail. The algorithms used, should identify defects without failure under different orientations of the target object. CAMERA 1 CAMERA 2 LED LAMP LED LAMP 1 1 90 45 45 flush width Fig. 2 Arrangement of Cameras and LED lamps with respect to the object Couple of areas where object recognition is used in automobile industry is – ? Detection of dimensional gaps in the body of the automobile in later stages of assembly ? Detection of missing fasteners on steel stampings Methodology – 1) Edges of the gap are highlighted by two LED lamps. Two stereo calibrated cameras (as shown in Fig. 2) measure the gap as a 3D distance. This method depends on the reflected LED light. Therefore, it is color independent and has an edge over

laser-based, gap-measuring systems because of this independence (Appearance-based Method=>We match the edges) (Kosmopoulos (2001)). FEW APPEARANCES AND ORIENTATIONS THE DIFFERENT OF THE OBJECT ARE 1 SYSTEM 2 DIMENSIONS OF THE FED INTO THE SYSTEM SYSTEM ARE STORED 3 4 A NEW ORIENTAION IS THE OBJECT IS PRESENTED TO THE IDENTIFIED USING SYSTEM FUZZY CLUSTERING TECHNIQUE Fig. 3 Steps involved in a general fuzzy clustering technique 2) Image segmentation is achieved by setting adaptive threshold for input images using labels that are predetermined by fuzzy clustering techniques. The learning is not supervised and

6the output status of the network is described as a fuzzy set.

Fig. 3 shows the working of system that uses fuzzy classification technique. The potential edges are determined by a measure of the fuzzy entropy (Appearance-based Method + Genetic Algorithm=>First an initial understanding of the appearances of the object is made, based on which different inputs are clustered. This being an automatic system learns about the different possible orientation on its own and searches for fasteners) (Boskovitz (2002) and Killing (2009)). 1.2 Food and Beverage Industry Quality and safety are of primary concerns of the Food and Beverage Industry. Inspection is difficult and labor intensive. As the industry grows in size; the need for accurate inspection increases. Manual identification in the industry is time consuming and, to an extend it is unreliable. This inaccuracy arises as a result of factors like inconsistency and subjectivity involved in human decision making. Apart from identifying the quality of the produce, the shape of the containers into which it is put also is important. This is why object recognition (machine vision) plays a major role in modern Food and Beverage Industry. 2 4 5 CAMERA 3 SYSTEM 1 CAMERA CAMERA OBJECTS ON A PRODUCTION LINE BASED ON THE IMAGES CAPTURED BY THE CAMERAS THE SYSTEM DECIDES WHICH OBJECT DISCARD Fig. 4 Cameras at different angles to capture images of a single object moving along a production line Few of the applications of object recognition in this industry include – ? Classifying empty and non-empty bottles, useful during recycling of bottles ? Automatic quality grading of fruits and vegetables Methodology – 1) The system is fed with certain basic features that are relevant for the classification. The system identifies many different appearances of empty bottles and learns different possibilities under a supervised environment (Feature-based Methods + Genetic Algorithms) (Blasco (2003), Brosnan (2004), Duan (2007) and Duan (2004), Liu (2010)). 2) Here, first the fruits or vegetables under inspection should be

detected. After this, the matrices of detected objects are compared to certain acceptable standards. For this, there is a need to maintain a database with matrices that store acceptable values for all the objects (Appearance-based Methods=>first identify the object based on edge matching and then comparing with values in the database) (Patel (2012)).

1.3 Fabric Industry

The main use of machine vision in Fabric Industry is to identify defected fabric. For long time, such identification processes were done manually by humans. This resulted in lack of efficiency and increased expenses. Computer vision can be used to identify defects by matching texture or color patterns. Most of the defects are vague and ambiguous. This emphasizes the need for efficient algorithms that can differentiate between normal and defected regions of fabric. There are three broad categories of approaches; statistical, spectral and model-based. Based on the type of features under inspection, one of the above approaches is chosen. The most important aspect in detection here is ability to identify local defects and have low false alarm rates (Bradshaw (1995), Kumar (2008) and Stojanovic (2001)).

Fig. 5 Architecture of a defect detection system Image courtesy - <http://scialert.net/> Fig. 5 gives a description of how computer vision is used in defect detection in fabric industry. The line scan cameras acquire images and the computer processes these images to make meaningful graphs based on which the fabric is classified defected or not. The main application of object recognition in Fabric Industry is to identify defects in texture and color of fabrics. Methodology (Mahajan (2009)) –

- 1) Statistical Approach – Uses spatial distribution of pixel values. Takes one (first-order), two (second-order) or more (higher-order) pixels at a time and works with estimates like the average and variance to identify defects. There are multiple ways to extract the texture features. These include first-order statistics, morphological operations, edge detection, fractal dimensions,

7co- occurrence matrix, rank order functions, eigenfilters, and many local linear transforms.

- 2) Spectral Approach – As the patterns in fabric are mostly reoccurring, it can be picturized as the spatial arrangement of certain texture primitives. In this approach texture primitives have to be extracted and then the spatial spacing of these primitives has to be generalized. This approach takes advantage of the high degree of periodicity in texture patterns and therefore cannot be used for detecting defects in random texture patterns. Fourier Transform, Gabor Transform, Wavelet Transform are used to extract texture features.
- 3) Model-based Approach – It is used not only to create an image model of the texture but also

to synthesize it. Essential perceived qualities of texture are captured by model parameters. Context dependent entities like pixels are modeled. The purpose of inspection is to gauge homogeneity (normal regions) and randomness (defected regions) in the material. This approach concentrates on detecting an alignment pattern in preprocessed images with the help of model based clustering. Defects can be detected by using approximate Bayes factor which involves statistical inference from the available data. 2. Robot Object Recognition ROBOTICS APPLICATIONS IMAGE STABILIZATION ROBOT HEAD POSE DETECTION - Optical Image Stabilization - Electrical Image Stabilization - Digital Image Stabilization - Head Pose detection using Local Invariant Features - Gaze direction determination Fig 6 Topics discussed under Robotics applications Robot Object Recognition deals with finding and understanding the identity of an object that is presented in the form of a video or image from a given set of labels or training examples. It is a daunting task to incorporate object recognition skills in a computer which matches the cognitive capabilities of humans. Still, substantial progression has been made in this field by the analysis of limited scope of distinct objects like road signs, fingerprints, handwritten digits, faces etc. Object recognition is used in various robotics applications such as image stabilization, robot head pose detection 2.1 Application of Image Stabilization in Robot Vision System Fig.7 An example of step by step image stabilization Image courtesy: <http://cdn.intechopen.com/pdfs-wm/10608.pdf> The vision system of a mobile robot makes use of the quantitative and qualitative features of the images obtained from the camera that is placed on the system. A robot achieves finest optimal performance when it satisfies both quantitative and qualitative features.

2Image stabilization is one of the most important qualitative

feature that must be satisfied by a robotic system. It involves removal of unwanted motions in the frame sequences that are captured by the camera mounted on the robotic system. This helps in enhancing the efficiency of the image processing algorithms that are

11applied to the images captured by the camera.

There are three major image stabilization methods: 1) Optical Image Stabilization (Cardani (2006) and

Tokyo (1993)): The movement of the camera is measured using a two- axis gyroscope. These signals are directed by a micro-controller to small linear motors which are used to move the image sensors. These sensors are fitted with

9a prism assembly that moves in the opposite direction of camera shaking, thus compensating for

the unwanted camera motion Camera Movement Gyroscope Image Sensors Motor Fig 8: Steps in Optical Image Stabilization 2) Electronic Image Stabilization (Oshima (1989) and Kinugasa (1990)): Same methodology used in Optical Image Stabilization except for the change that instead of changing the prism directions, the image is provided with pixel transformations in the software. 3) Digital Image Stabilization: This makes use of image processing algorithms. It has motion estimation processing which determines global motion vectors with the help of local motion vectors. This is followed by the use of motion compensation processing which produces smooth images by generating motion compensation vectors. Methodology – When a robot moves in its visual field, there will be positional changes in the objects encountered by it, as a result of its locomotion. A local control loop (Fig 5) is used in the robotic head as a replication of the Vestibulo-Occular Reflex in human brain. This strategy is used to predict changes in the images in the robotic head. An inertial sensor measures the horizontal component of the disturbances in the image. This signal is used by

2the look- ahead controller to generate the control signal for degree of

freedom control pan (G_c) (Amanatiadis (2010)). This in turn produces an opposite order against the movement of

10Gp. This way, the rotational component of the disturbances is

avoided. Then, using a differential technique on two sequential image frames, the horizontal retinal

slippage is computed. This is used as a feedback signal that optimizes image stabilization. Similar methodology is used for vertical disturbances. MOTION ESTIMATION

2Input image Local motion estimation Global motion vector estimation
MOTION COMPENSATION Compensating motion vector estimation Image
Stabilized output compensation image Fig. 9 DIS Architecture Image

courtesy: <http://cdn.intechopen.com/pdfs-wm/10608.pdf> 2.2

4Robot Head Pose Detection Robot Head Pose Detection is

a major functionality of

4robot gaze direction determination system. The process of

determining where another robot is looking at is termed as Robot gaze direction determination. This technique is helpful in situations where the robots' situational analysis ability is important so that the competitive, co- operative and synchronization skills of the robots are enhanced (Eg: Robot Soccer). The robot head pose detection system has two major processes. Every observed scene will have certain scale invariant local descriptors. These descriptors (robotic head prototypes) are computed first. Then these are matched against those descriptors that are

14already stored in a database. The robot

heads are pictured under different view angles (Fig 1). The prototypes that are matched correspond to each of these images.

1 **After the robot head pose detection, the**

factors such as the

1 **head model of the observed robot, the robot head pose**

that is detected

1 **with respect to the observing camera and**

1 **3- D pose of the observing robot's camera**

are used to find the robot gaze direction. Fig.11 Robot Head prototypes with their SIFT's Image courtesy: Locomilla (2008) 2.1.1 Detection of

1 **Head Pose using Local Invariant Features**

A database is stored with robot head prototype images. These image descriptors are compared with that of the input image so as to obtain the robot head pose. The prototypes are based on the various angular views of a robot head. The matching process is carried out in 4 different stages (Lowe (2004)). 1) Local interest point Generation 2) SIFT descriptors computation 3) SIFT matching using closest descriptors 4) Transformation computation and hypothesis rejection test After applying these stages, the highest probable affine transformation is performed on the robot heads, if found any. This transformation and matched reference image identity together is used in finding the robot head pose. 2.1.2 Gaze Direction Determination The direction at which an observed robot is gazing is determined using the following

information. 1) Position and orientation of the observing robot's camera in global coordinates 2) The angle at which the prototype is viewed 3) The observed robot's angle of rotation and distance The methodology is given in fig.12 Observing robot's Known a priori camera pose If

1 camera is fixed in global coordinates, using the

techniques of

1 self-localization and joints information, the

robot estimates it on its own. View angle of the Defined and fixed along with the creation of model prototype database Distance and

1 Using information of head detection process rotation angle of

Resolution and angle of view of observing camera observed robot Fig.12 Gaze direction determination 3. Remote Sensing REMOTE SENSING SATELLITE REMOTE SENSING - Detection of buildings, roads, urban areas - Spy satellites Fig.13 Topic discussed under Remote Sensing Remote sensing is the one of the most important areas in which object recognition is used. The reason for this is simply because of the fact that in remote sensing there is no contact required to study the target object. Detection and classification of objects is achieved by the processing of propagated signals. This technique is used to study planets and stars in the galaxy. It also helps in studying and monitoring resources like forests, agriculture and water in remote locations and measuring sea surface temperatures. Remote sensing is broadly categorized into Passive and Active remote sensing. Passive remote sensing detects the reflection patterns of sunlight to interpret the scene, whereas Active remote sensing emits signals that are reflected by the objects in scene. These reflected signals are processed for an understanding of the scene. In general, the sensors are likely to aerial, so that large geographical areas can be covered. Role

12of Image Processing comes after the images are obtained by the sensors. The

systems have to use algorithms to recognize patterns in the image based on the initial input given. If genetic algorithms are incorporated, the system can update information about objects. SENSOR TARGET SCENE REFLECTED RAYS FROM TARGET TO SENSOR (a) Passive Remote Sensing ENERGY EMITTED BY SOURCE SENSOR TARGET SCENE REFLECTED RAYS FROM TARGET TO SENSOR (b) Active Remote Sensing IMAGE FROM SENSOR LEARNING AUTOMATICALLY 1) IDENTIFY LOCAL DESCRIPTORS 2) USE FILTERS FOR EXTRACTION OF EDGES 3) DEVELOP DESCRIPTOR VECTORS COMPARING THE DESCRIPTOR VALUES WITH EXISTING VALUES THE OBJECTS FOR SERVER OR 1) APPLY ADABOOST ON FEATURE DETECTION REPRESENTATION OF IMAGE (c) Image Processing Steps Fig.14 Different types of Remote Sensing 4.1 Satellite Remote Sensing Energy emitted by satellite for detecting objects Reflected radiation (a) Passive Remote Sensing (b) Active Remote Sensing Fig.15 Different types of Satellite Remote Sensing Image courtesy -

5<http://www.crisp.nus.edu.sg/~research/tutorial/intro.htm> Satellite Remote Sensing

deals with sensors on satellites. These sensors observe Earth all the time. These satellites are either stationary or revolve around Earth. It collects visual data about Earth and its atmosphere. Different aspects such as the distribution of natural resources such as forests, water and even minerals can be obtained from Satellite Remote Sensing. Information regarding the terrain can also be acquired. On observing the atmosphere, weather patterns can be predicted and also volcanic ash can be observed in case of a volcanic eruption. Reflected Infrared rays are used to detect surface temperatures. This way, Satellite Remote Sensing helps in studying and monitoring the planet we live on. The source of energy used should be carefully determined as absorption and scattering can take place in the atmosphere. Few areas where Satellite Remote Sensing is used – ? Urban area, road and building detection (Object detection in general) ? Spy satellites Methodology – 1) In general, object detection from remote sensing images is carried out by using the local descriptors and functions to detect edges. Local descriptors include color, shape and texture of images. Occlusions and global geometric distortions are overcome as

local descriptors are used. Filters such Gabor filter can be used for extraction of features such as edges. Filters with different frequencies and orientations are used to achieve this. The main advantage with Gabor filter is that its working is analogous to the human visual system. Hence, can be efficiently used for representation and discrimination of textures. Features are represented by descriptor vectors and therefore appropriate values for different objects must be initially stored in the system. The obvious disadvantage with this system is that of considering every possible case for differentiation of objects. (Feature-based Methods + Template Management system=>Compares the descriptor values of the detected objects with the values in the system to differentiate between objects). 3.1 3.2 3.3 Fig.16 Haar-like features Image courtesy -<http://docs.opencv.org/http://docs.opencv.org/> 2) Another approach to this problem is using AdaBoost (Adaptive Boosting) classifier. In this approach Haar-like structures are used to interpret features of the image. Haar-like features are digital image features. AdaBoost classifier selects a fixed number of these features depending on the ease to differentiate objects based on these features (Feature-based Methods=>Identifying Haar-like features and using it to differentiate between objects) (Ke (2009)). Fig. 3 shows the different Haar-like features that can be used for feature extraction. The system is initially fed with objects of interest (buildings, roads and urban areas) also called positive images (all images are scaled to a predetermined size) and also few arbitrary images called negative images. The trained classifier applied to the input will return 1 if the input plausibly shows the object, otherwise it returns 0. After several stages of applying the basic classifier, certain regions are rejected if it has no chance of containing the object. The AdaBoost classifier is used to not only to select features in manner that the system is fast, but also to increase the accuracy (Viola (2001)).

4. Medical Applications

MEDICAL APPLICATIONS LIVER TUMOR DETECTION AUTOMATIC DETECTION OF ROI IN MAMMOGRAPHY DETECTION OF CANCER CELLS - - - ROI Thresholding Detection of Tumor - Closed loop control scheme - Segmentation or detection - Feature extraction - Classification or decision making - Spectroscopy to determine intermediate values - Extract features using Hyperspectrum Fig.17 Topics discussed under Medical applications

Due to low signal to noise ratio, manually segregating the medical images is out of the question. Moreover, the presence of imaging artifacts makes this task even more difficult. Medical imaging systems are used to mainly to detect tumor cells, cancer cells and lesions in the human body. This task is accomplished by magnetic resonance (MR), X-ray, ultrasound scan, CT scan. Sometimes a combination of these techniques may also be applied to various internal organs. This is done by measuring the volume and shape of the organs in 3D imaging. Usually a

13 **region of interest (ROI)** is defined beforehand **to** separate **the** relevant details from **the**

background details. 4.1 Liver Tumor Detection from CT Scan Images Human liver is something that is very delicate. It should be given utmost care and is easily vulnerable to diseases. Here we use the computer aided diagnostic of the liver to detect tumors, lesions and vessels. This computer aided diagnostic image is obtained from a CT- Scanner. The detection method is applied to the image that is obtained from the CT scanner. One limitation of the image that is obtained directly from the CT- scanner is that, it may be blur. So we use image smoothening and thresholding techniques to enhance the quality of the image (Fasquel (2002)). Here is an image that is obtained from the CT- Scanner. Various operations are performed on it. (a) The image obtained from the CT- Scanner. (b) Image after thresholding. (c) Image obtained after adding A and B (d) The dark regions could be a tumor (a) (b) (c) (d) Fig. 18 Spatial Operations performed on CT-Scanned image of liver Image courtesy: Fasquel (2002) Methodology – The ROI containing the tumor is searched and identified. Tumors generally come in different sizes. Hence it is difficult to identify the region containing the tumor. After identification, the image is thresholded .As a result the granular aspects of the image are enhanced. In order to remove the grains in the image, a morphological alternate sequence filtering is performed on it. The resultant binary filtered image is closed using a much larger structuring element. This method is applied to all ROIs. Once the entire image is processed, regions that are tumorous can be identified based on comparison with empirical data. 4.2

8 **Automatic Detection of Regions of Interest in Mammography based on** histogram and texture **analysis.**

Breast cancer has become

3 **one of primary causes of women mortality.**

Thus early screening and detection is necessary if the numbers are to be brought down. Early

3detection of breast cancer increases women's chances **of survival.**

It can also be cured easily. The number of mammograms a specialist analyses is large and among them only a few of them contain malignant tumor. The problem lies in detecting lesions less than 1 mm in diameter. So to improve our chances of detection, we bring in texture and histogram analysis and use it to detect lesions (Tweed (2002)). A computer aided diagnostic system may come in handy for radiologist and can be used for early detection of breast cancer. Methodology – Segmentation Classification or Feature detection extraction or decision making Fig.19 Methodology followed in mammography In order to detect a suspicious region in a mammography, we apply masks on the image. The mask we use here is circular because we want detectors that are invariant in rotation. For each mammography, hundreds of texture and histogram features are extracted from the mask. Then this is compared with the features extracted from the region of interest. (a) Mass type lesion marked by radiologists (b) Texture analysis (c) Histogram analysis (d) Joined analysis Fig.20 Mammography Analysis Image courtesy – Tweed (2002) For the selection of Region of Interest, we use Texture analysis and histogram analysis. 1) Texture Analysis - Human eye has an amazing power to discriminate between objects and surfaces. In a similar way, computers can also be programmed to do the same. This task becomes challenging when the ROI is very small. Textures are repeated patterns. Each ROI contains texture. This texture is compared with empirical data for determining tumorous regions. For this we rely on various enhancement techniques such as smoothening and sharpening that can only be done by computers. On applying these processes the image is enhanced. Now it becomes easier to discriminate the regions containing tumor from the normal regions (Tweed (2002)). 2) Histogram Analysis –Tonal distribution of an image is represented using a histogram. Histogram is a graphical representation of an image. The graph is obtained by plotting the no of pixels corresponding to each tonal value. A histogram provides full tonal distribution of an image to the viewer. The number of light pixels within a tumorous region is taken into account. For this two threshold values are used. One for determining the intensity value of the pixel and the other for determining the number of pixels in ROI having intensity greater than the threshold intensity (Tweed (2002)). Detection of Cancer Cells in Brain Biopsy is the only way known by humans for detection of cancerous cells in the brain. If there was a way to exactly pinpoint the location of the cancerous cells, it

could decrease the no of biopsies to be performed on a human. But precise detection of cancer cells in the brain is extremely cumbersome provided the delicate structure of the brain. Scientist are working on a new imaging pen which can identify the Region of Interest (ROI) containing the cancer cells. Advanced research is still going on. This imaging pen uses a combination of Raman Spectroscopy, diffuse reflectance spectroscopy and laser induced spectroscopy simultaneously to look into the lesion (Gardiner (1989)). Cancer is caused by repeated multiplication of cells. So a region where cancer cells are found will contain more no of cells compared to other regions. The ROI is found out by analyzing the oxygen consumption of the cells as it should consume a lot more Oxygen compared to the other cells around (Khoobehi (2004)). The imaging pen is connected to a computer which performs the image processing.

Methodology – ? Spectral Approach - Vibrational, rotational and other low-frequency modes are recorded with the help of scattering and reflecting of particles in the electromagnetic spectrum. The representation of the brain is made pixel by pixel, giving each one its spectral values. Using Hyperspectral Imaging in conjunction with the values obtained from spectroscopy, composition of the scene can be measured. Hyperspectral Imaging gives fine details of the scene as it uses a wide range of wavelength. In this case, composition of oxygen is measured (Chang (2003)). The values obtained have to be compared with the available standard values. This way the system detects presence of cancer cells in brain.

TAKE INPUT
 IMAGE Carry out spectroscopy and obtain values of low- Obtain spectral values for frequency modes
 pixels using Hyperspectral Imaging COMPARE WITH STANDARD Cancer cells in brain VALUES Values
 for composition of identified Oxygen Fig. 21 Steps involved in detecting cancer cells in brain This
 technique has a certain advantage as it allows for accurate segmentation and classifications. At the same
 time, it is time consuming and complex.

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