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Knowledge Based System based on Fuzzy Logic for Digital Image Processing

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Abstract

Digital Image Processing has been increasingly used in several fields with great impact. This paper describes the basic design & working of a knowledge based system based on Fuzzy Logic using the digital image processing techniques for identification of hidden or misplaced objects. The automated system will aid in search & rescue missions among other image processing applications. This will help in bringing down the search time & help in faster identification of concerned objects.

Keywords

Digital Image Processing, Machine Learning, Artificial Intelligence, Systems Engineering, Fuzzy Logic.

1. Introduction

Image processing has become an integral part of the modern manufacturing facilities with the technology being employed in various stages of quality assurance & testing – both automatic & semi-automatic. The basic working of system acquiring of image through different means, which is then processed either by a human or automated algorithm & subsequently the result is displayed. In most of the cases, systems are concerned with defected surface, cracked parts, detection of metallic or foreign unwanted materials or parts among others.

The common steps that are used for inspection of any image include [1],

Step 1: To acquire single or multiple image of the object under evaluation.
Step 2: Pre-processing of the acquired images.
Step 3: Image segmentation.
Step 4: Extraction of Object & features of the segmented image.
Step 5: Detection of the feature under observation (deformities, faults, cracks etc.)
Step 6: Final result of the inspection.

Image acquisition basically deals with the generation of images of the concerned object through different means & transferring it to the computing device for further processing. During the stage of image pre-processing, different techniques are used for enhancing the image to make it suitable (contrast enhancement, noise removal, background removal etc.) [2][3] for intermediate image processing. Image segmentation is one of the most important steps in automated image processing, wherein the image is partitioned into different classes of objects. Most thresholding methods currently rely on simple thresholding algorithm [1]. However, since the object under inspection may be made up of various materials of varying thickness which is a function of random variable, such simple thresholding algorithm cannot be applied. To overcome this problem, other methods based on artificial intelligence are applied, such as propagation neural networks, Kohonen neural networks, Hopfield neural networks etc. [1]. During the step of object & feature extraction, the method employed will extract & compute the features as per requirement from the segmented image. The features under observation will depend on specific application & requirements of the system.

The detection of the features stage is more like a classification or pattern recognition (PR) step[1]. This step will rely on the features & objects extracted in the previous step. This step will help in judging whether the object under observation is normal or defective. It will involve comparing of the extracted features with the information (images, features, objects etc.) already present in the database. In case of semi-automatic inspection, human inspectors will compare the obtained image with sample image already present to check the features. The final result will depend on the outcome of the previous step. If all the features & objects are found to be in place, the object under observation is deemed to be fit.

Digital image processing is used for,

a. Classification of images
b. Feature & Object extraction

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c. Multi scale image analysis
d. Pattern recognition
e. Projection

With the advancements in science & technology, the scope & need for image processing increases, because of the growing importance of large & complex scientific investigation or research.

2. Literature review

2.1 Image

An image as defined in real world is a function of two real variables, for instance, a (x,y), where a is the amplitude (e.g. brightness) of the image at real coordinates (x,y). Also, images may have sub-images or region of interests (ROI). Thus, it may also be noted that images frequently contain collection of objects each of which can be basis of a region [4].

2.2 Digital Image Processing

Digital image processing can be defined as use of computer algorithms to process digital images. Compared to analog image processing, digital image processing has many advantages. It allows a much wider range of algorithms to be applied on the input data & also helps in avoiding problems such as build ups of noise & signal distortion during image processing.

2.3 Image Compression

Image compression can be defined as an application of data compression on digital images. Image compression can be further classified as lossy or lossless. Lossless compression is preferred for artificial images such as technical drawings, icons or medical imagery, image scan for archives etc. Lossless compression is generally preferred for high value content. Lossy compression is suitable for natural images where minor loss of fidelity is acceptable.

2.4 Filter

A filter is a device that classifies & allows only certain things to pass through it. Filters can be classified into following types,

2.4.1 Low Pass Filter

Low pass filter allows low frequencies to pass through it as shown in figure 1.

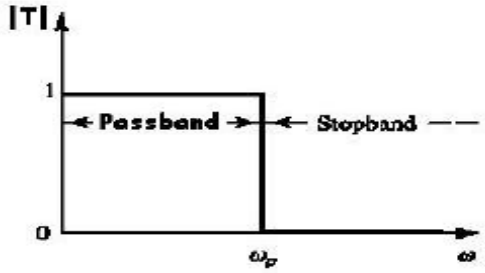

Figure 1: Low pass filter [4]

2.4.2 High Pass Filter

High pass filter allows high frequencies to pass through it as shown in figure 2.

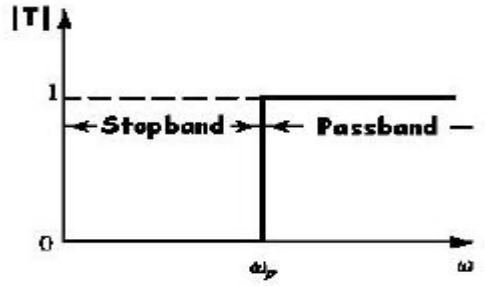

Figure 2: High pass filter [4]

2.4.3 Fast Fourier Transform (FFT) Filter

FFT filters provide a precisely controlled low & high pass filtering using a Butterworth characteristic [4]. The image is converted into spatial frequencies using a FFT, than an appropriate filter is applied & image is converted back using inverse FFT.

A FFT computes the discrete Fourier transform of a sequence or its inverse. It converts the signal form the original domain to representation in frequency domain & vice versa.

3. Proposed System

3.1 System Background

3.1.1 Search & Rescue

Idea of search & rescue robots emerged at the beginning of the 1980's. However, real developments in the field began only post 2001. The first research on search & rescue robot began after Oklahoma City Bombing in 1995. In 2001, mobile robots of different sizes were used during World Trade Centre disaster [5].

Thus started research & development of intelligent robots equipped with advanced sensors & systems. There are several types of calamities that can require search & rescue operation on a large scale, for instance, wildfire, tsunami, earthquakes etc. Few research teams that work on search & rescue missions are [5],

a. CRASAR (Centre for Robot Assisted Search & Rescue) - University of South Florida
   This is human operated robot which can be driven in places requiring search & rescue operations.
b. Utility Vehicle for Search UVS - Kobe University, Japan

These are several homogeneous small robots that can link together to form a large robot that can climb large obstacles.

c. Kohga - University of Tokyo

These are snake robots that can explore small sites or borrows to look for human signs.

3.1.2 Recovery of misplaced objects

During everyday life there are certain times when we misplace objects & then waster several anxious moments to search for the same. The commonly misplaced objects include wallets, pen drives, keys etc. The proposed system can also be employed to aid in searching for objects faster when produced on mass scale bringing down the cost. Though, it is possible to invest time & search the whole surrounding to find the lost object, however, it would only lead to severe stress, anxiety & mental trauma apart from wastage of precious time.

Statistics show that 9 out of 10 people misplace items that they frequently use & the time to recovery is almost thrice of what it should have generally taken [6]. With the rising number of gadgets & devices, the probability of misplacing one raises several fold.

3.1.2.1 Reason for lost objects

Table 1 shows the reasons for losing an object according to their probability across several age groups.

Table 1: Reason for lost objects [6]

AGE	REASON
Young (15 – 30)	Negligence – 65%
	Unfocused – 6%
	Object not Visible – 5%
	Related to Memory – 12%
Middle – Aged (30 – 50)	Negligence – 31%
	Unfocused – 19%
	Object not Visible – 4%
	Related to Memory – 8%
Old (50 – 80)	Negligence – 13%
	Unfocused – 19%
	Object not Visible – 4%
	Related to Memory – 8%

3.1.2.2 Strategies to find lost objects

The common strategies involved to find the lost items / objects can be grouped as follows [6],

a. Retrace – Areas are searched with respect to sequential basis of a person's prior physical locations.
b. Memory – Areas are searched based on person's memory of prior interactions of the object.
c. Exhaustive Search – All possible areas are searched.
d. Locus Search – Areas where object is commonly found / located is searched.
e. Delegation Search – Person other than those requiring it searches for the object.

The most commonly used strategies to find lost objects were Locus search with 33%, Exhaustive search with 24% & retrace with 19%. The remaining strategies are used in 11% of the cases each [6].

3.2 Block Diagram of the System

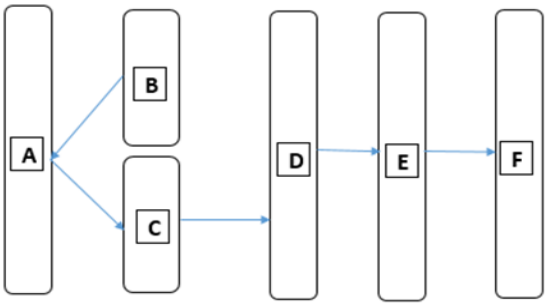

Figure 3: Block diagram of the proposed System

Figure 3 shows the block diagram of the proposed system. The various alphabets depicted in the image concerns the following,

A – Area to be searched
B – Transmitter
C – Receiver
D – Image Pre-Processing
E – Image Processing
F – Final Result

3.3 System Working

User will scan the area of interests using the transmitter & receiver. The transmitter will transmitter waves will bounce back from the area under observation & will be caught back by the receiver. The receiver will then transmit the image to image pre-processing. Here, the noise & other unwanted things will be removed from the image so as to make it useful for the next step. During the image processing stage, the so obtained image will be either manually or automatically be compared to the image in the database so as to find whether the object under search is found or not.

3.4 System Modules

3.4.1 Scan Module

The scan module will basically consists of 2 major components,

a. Transmitter
b. Receiver

We are at present working on finding most appropriate waves to be used for optimal results. Though at present SONAR looks quite promising.

3.4.2 Comparison Module

The comparison module will help in determining whether the object under search has been identified or not. The comparison module can be broadly classified into 2 types,

a. Manual Comparison

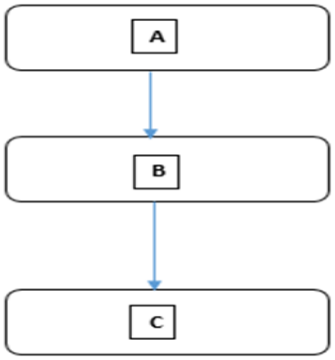

Figure 4: Manual Comparison

Figure 4, shows the block diagram for manual comparison. The various alphabets depicted in the image are,
A – Image after Pre – Processing
B – Computing System
C – Screen for Human interaction

The image after pre–processing i.e. removing all unwanted noise & other processing is sent to computing system where it will be rendered on the screen for human interaction. Human can take decision on basis of the image rendered.

The main drawback of this system is that it will require a constant human interaction to function.

b. Automatic Comparison

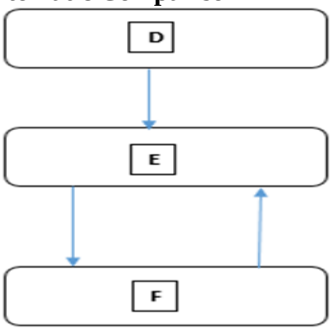

Figure 5: Automatic Comparison

Figure 5, shows the block diagram for automatic comparison. The various alphabets depicted in the image are,

D – Image after Pre – Processing
E – Computing System
F – Database of image for Comparison

The image after pre – processing i.e. removing all unwanted noise & other processing is sent to computing system where it will be compared with the images stored in the database to find whether the object under consideration has been found or not. This ensures speedy results.

3.4.3 Input Module

Through the input module, the user will basically be able to input the drawings that need to be identified or searched. The drawings can be scanned or be fed by any other means in the system.

3.5 Use of Artificial Intelligence

We plan to apply & extend artificial intelligence based techniques in our system so as to expedite the process & for accurate results. The Fuzzy Logic approach is being evaluated for the system.
Fuzzy Logic is an easy & convenient approach for mapping an input space to output space. When the

Fuzzy Logic approach is applied to Digital Image Processing, it provides the following advantages [1],

a. Great flexibility, due to the ease of modifying or adding more functionality to the system.
b. Greater tolerance towards non precise data.
c. Experience of human experts can be used as scaffolding for Fuzzy Logic.
d. Fuzzy logic is based on natural language which has evolved over several centuries & is convenient & easy to use.

4. Expected Outcome

With the development of the proposed system, we expect to achieve the following,

a. Autonomous working bot which can be deployed in search & rescue operation.
b. Faster image processing based on data mining & fuzzy logic.
c. Small hand held device for personal use so as to expedite the search of objects in case they are misplaced.
d. Development of technology to search hidden objects with minimal identification.
e. Development of technology wherein people are able to fed diagrams, sketches or images in the system & scan the area to search for it.

5. Conclusion

With the advancements in the field of Artificial Intelligence, Data Mining & Digital Image Processing, it is possible to develop a system where in users are able to input the sketches or images of object under search & then scan for them. The system can also be automated to scan the area & compare the obtained image with that in the database, thus minimizing human interference. This is particularly important in cases where trained human resource is scarce, but the search & rescue operation needs to be performed in minimal time like natural calamities to improve the chances of finding live humans.

6. Future Scope

With the outline of the proposed system discussed in this research paper, future work will revolve around developing the algorithm for image processing & comparison. Also, the input module for user needs to be developed with testing of several kinds of waves for image gathering so as for optimal results.

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