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Sharda. A. Chhabria
*G.H. Raisoni College of Engineering, Nagpur, Maharashtra-440016 (India)*, sharda_chhabria@yahoo.co.in

Ranjana S. Shende
*G.H. Raisoni College of Engineering, Nagpur, Maharashtra-440016 (India)*, ranju_shende@yahoo.com

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# Connected Component Algorithm for Gestures Recognition

**Sharda. A. Chhabria & Ranjana S. Shende**
G.H. Raisoni College of Engineering, Nagpur, Maharashtra-440016 (India)
E-mail: sharda_chhabria@yahoo.co.in, ranju_shende@yahoo.com

***Abstract*** - This paper presents head and hand gestures recognition system for Human Computer Interaction (HCI). Head and Hand gestures are an important modality for human computer interaction. Vision based recognition system can give computers the capability of understanding and responding to the hand and head gestures. The aim of this paper is the proposal of real time vision system for its application within a multimedia interaction environment. This recognition system consists of four modules, i.e. capturing the image, image extraction, pattern matching and command determination. If hand and head gestures are shown in front of the camera, hardware will perform respective action. Gestures are matched with the stored database of gestures using pattern matching. Corresponding to matched gesture, the hardware is moved in left, right, forward and backward directions. An algorithm for optimizing connected component in gesture recognition is proposed, which makes use of segmentation in two images. Connected component algorithm scans an image and group its pixels into component based on pixel connectivity i.e. all pixels in connected component share similar pixel intensity values and are in some way connected with each other. Once all groups have been determined, each pixel is labeled with a color according to component it was assigned to.

***Keywords*** - *Human computer interaction, Image processing, Gesture recognition, Connected Component algorithm.*

## I. INTRODUCTION

In image processing, a connected components algorithm finds regions of connected pixels which have the same value. Connected component algorithm works by scanning an image, pixel-by-pixel (from top to bottom and left to right) in order to identify connected pixel regions, **i.e.** regions of adjacent pixels which share the same set of intensity values. Gesture recognition is an important aspect of pattern recognition. Gesture recognition has been a very popular research topic in recent years. It covers a wide variety of applications in commercial and law enforcement, including security system, personal identification, image and film processing, and human-computer interaction. Pattern recognition is the scientific discipline whose goal is the classification of objects into a number of categories or classes. Depending on the application, these objects can be images or signal waveforms or any type of measurements that need to be classified [9]. A complete Extracting and labeling of various disjoint and connected components in an image is central to many automated image analysis applications. The interaction between human and robot is definitely one of the major issues in the 21st century. This is due to the fact that although nowadays many tasks are being performed merely by robots, however, there are many cases in which robots either need the supervision and direction of a human being or they require collaboration with people to receive and process corresponding data to start a transaction or finish an assignment. Robots are gaining an ever increasing foothold in society, with the particular uses of teleported robotic arms in fields such as medical surgery, remote manipulation of objects in hazardous environments, weaponry for warfare and industrial automation attracting a lot of research and development attention. It is investigated that service and personal care robots will become more prevalent at home in the near future and will be very useful in assistive operations for human care, particularly the elderly and disabled. Hand gestures are a very usual type of human interaction and can be used efficiently in HCI. Feasibility of controlling home appliances using hand gestures and would present an opportunity for a section of the aging population and disabled people to lead a more independent life. Hand & Head gestures recognition is a promising research field in computer vision. Its most appealing application is the development of more effective and friendly interfaces for human-machine interaction, since gestures are a natural and powerful way of communication.

## II. LITERATURE REVIEW

A body of literature survey suggests that people naturally tend to do activity with which they interact. It also investigated how people use speech and gestures when interacting with system. In the concept of multimodal user interfaces, users are able to communicate with computers using the very modality that best suits their current request. Apart from mouse or keyboard input, these modalities include speech, handwriting or gesture [1]. Gesture recognition is the process by which gesture made by the user are known to the system. Gestures components are the Head and hand poses. Gestures are recognized using rule-based system according to predefined model with the combinations of the pose classification results of three segments at a particular image frame. Pattern recognition is the scientific discipline whose goal is the classification of objects into a number of categories or classes. Latest work has been done in genetic algorithm and principle component analysis and neural network. A genetic algorithm is an iterative process that consists of a constant-size population of individuals, each of which is represented by a finite string of symbols known as the genome. These strings of symbols encode possible solutions in a given problem space referred to as the search space. This search space consists of all the possible solutions to a problem. Genetic algorithms are usually applied to search spaces that are too large to be searched exhaustively. To detect gesture movement and interact with computer using hand and head movement different technique are available to recognize gestures.

- Principle component Analysis: It is a classical feature extraction technique [3] widely used in the field of pattern recognition and computer vision.
- Support Vector Machines: It is a classical statistical technique for analyzing the covariance structure of multivariate data.
- Neural Network and Fuzzy ‘c’ Clustering Method.
- Self-Growing and Self-Organized Neural Gas (SGONG) network [4].
- Spatio-Temporal Feature-Extraction Techniques [5].
- Linear discriminate analysis
- Independent component analysis.

As compared to many existing algorithm the advantages of connected component between the technology and conventional labeling algorithms are: (1) all conventional label-equivalence-based algorithms scan an image at least twice, whereas this algorithm scans an image only once; (2) all conventional label-equivalence-based algorithms assign a provisional label to each object pixel in the first scan and re-label the pixel in the later scan(s), whereas this algorithm assigns a provisional label to each run in the only scan, and after resolving label equivalences between runs, by using the recorded run data, it assigns each object pixel a final label directly. Therefore, relabeling of object pixels is no longer necessary.

## II. CONNECTED COMPONENT ALGORITHM

The algorithm makes two passes over the image: one pass to record equivalences and assign temporary labels and the second to replace each temporary label by the label of its equivalence class.

**4-Connected**

4-Connected pixels are neighbors to every pixel that touches one of their edges. These pixels are connected horizontally and vertically. In terms of pixel coordinates, every pixel that has the coordinates

**$(x \pm 1, y)$ or $(x, y \pm 1)$** is connected to the pixel at **$(x, y)$**

**8-Connected**

8-connected pixels are neighbors to every pixel that touches one of their edges or corners. These pixels are connected horizontally, vertically, and diagonally. In addition to 4-Connected pixels, each pixel with coordinates **$(x \pm 1, y \pm 1)$ or $(x \pm 1, y \mp 1)$** is connected to the pixel at **$(x,y)$**.Connectivity checks are carried out by checking the labels of pixels that are North-East, North, North-West and West of the current pixel (assuming 8-connectivity). 4-connectivity uses only North and West neighbors of the current pixel. The following conditions are checked to determine the value of the label to be assigned to the current pixel (4-connectivity is assumed)

**North and West neighbors**

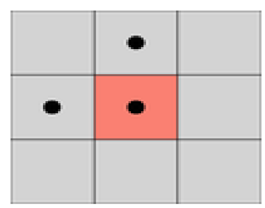


Figure 1: Labels of pixels that are North and West

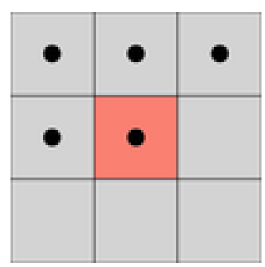


Figure 2: Labels of pixels that are North-East, North, North-West and West

**Conditions to check:**

1. Does the pixel to the left (West) have the same value?

   **Yes** - We are in the same region. Assign the same label to the current pixel

   **No** - Check next condition

2. Do the pixels to the North and West of the current pixel have the same value but not the same label?

   **Yes** - We know that the North and West pixels belong to the same region and must be merged. Assign the current pixel the minimum of the North and West labels, and record their equivalence relationship

   **No** - Check next condition

3. Does the pixel to the left (West) have a different value and the one to the North the same value?

   **Yes** - Assign the label of the North pixel to the current pixel

   **No** - Check next condition

4. Do the pixel's North and West neighbors have different pixel values?

   **Yes** - Create a new label id and assign it to the current pixel

The algorithm continues this way, and creates new region labels whenever necessary.

On the first pass:

1. Iterate through each element of the data by column, then by row (Raster Scanning)
2. If the element is not the background
   i. Get the neighboring elements of the current element
   ii. If there are no neighbors, uniquely label the current element and continue
   iii. Otherwise, find the neighbor with the smallest label and assign it to the current element
   iv. Store the equivalence between neighboring labels

On the second pass:

1. Iterate through each element of the data by column, then by row
2. If the element is not the background
   i. Re-label the element with the lowest equivalent label

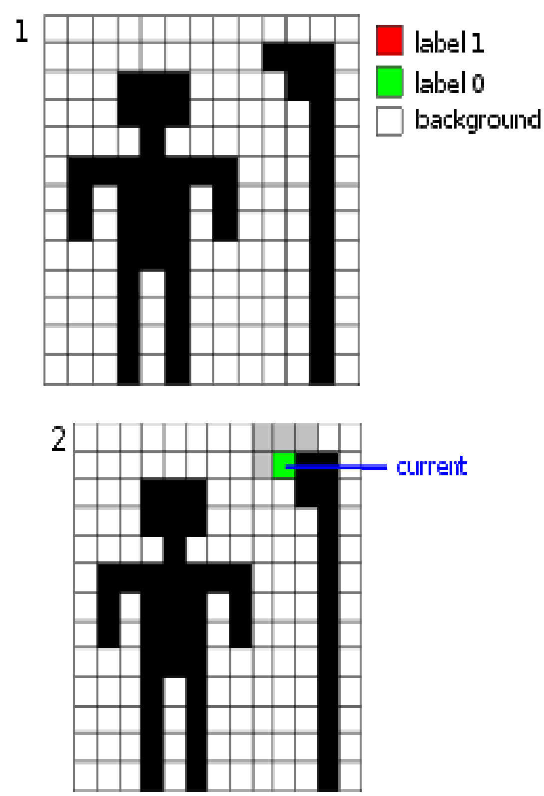
Here, the background is a classification, specific to the data, used to distinguish salient elements from the foreground. If the background variable is omitted, then the two-pass algorithm will treat the background as another region.

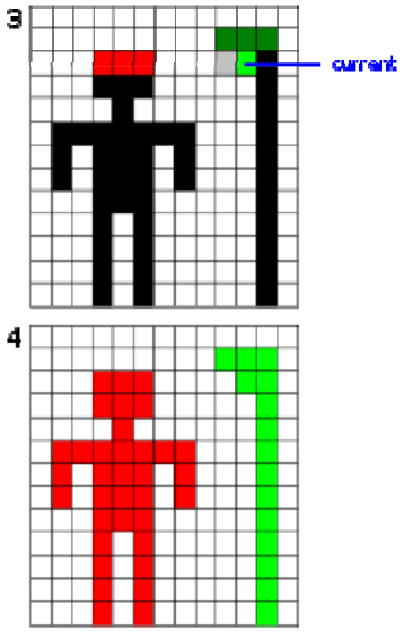
**Algorithm:**

Connected Component Matrix is initialized to size of Image Matrix.

1. A Marker is initialized and incremented for every detected object in the image.
2. A counter is initialized to count the number of objects.
3. A row-major scan is started for the entire image.
4. If an object pixel is detected, then following steps are repeated till (Index !=0)
   1. Set the corresponding pixel to 0 in Image.
   2. A vector (Index) is updated with all the neighboring pixels of the currently set pixels.
   3. Unique pixels are retained and already marked pixels are removed.
   4. Set the pixels indicated by Index to 1 in the Connected Component Matrix.
5. Increment the Marker for another object in the Image.

In this way this algorithm separate foreground from background and makes a pattern of hand and head gestures. According to stored pattern corresponding action (Left, Right, Forward and Backward) is performed by hardware.






Sample graphical output from running the two-pass algorithm on a binary image. The first image is unprocessed, while the last one has been recolor with label information. Darker hues indicate the neighbors of the pixel being processes.

## III. RESEARCH METHODOLOGY TO BE EMPLOYED

The organization of a computer vision system is highly application dependent. Some systems are stand-alone applications which solve a specific measurement or detection problem, while others constitute a sub-system of a larger design which, for example, also contains sub-systems for control of mechanical actuators, planning, information databases, man-machine interfaces, etc. The specific implementation of a computer vision system also depends on if its functionality is pre-specified or if some part of it can be learned or modified during operation. There are, however, typical functions which are found in many computer vision systems.

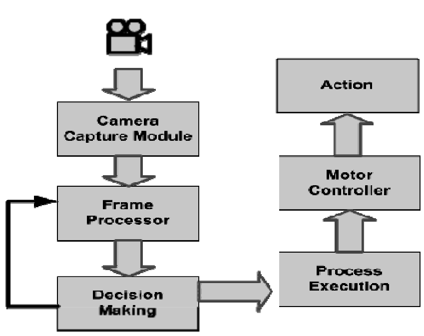



Figure 5: Processing Flow

### A. *Image acquisition:*

A digital image is produced by one or several image sensors, which, besides various types of light-sensitive cameras, include range sensors, tomography devices, radar, ultra-sonic cameras, etc. Depending on the type of sensor, the resulting image data is an ordinary 2D image, a 3D volume, or an image sequence. The pixel values typically correspond to light intensity in one or several spectral bands (gray images or color images), but can also be related to various physical measures, such as depth, absorption or reflectance of sonic or electromagnetic waves, or nuclear magnetic resonance.

### B. *Pre-processing*

Before a computer vision method can be applied to image data in order to extract some specific piece of information, it is usually necessary to process the data in order to assure that it satisfies certain assumptions implied by the method. Examples are

- Re-sampling in order to assure that the image coordinate system is correct.
- Noise reduction in order to assure that sensor noise does not introduce false information.
- Contrast enhancement to assure that relevant information can be detected.
- Scale-space representation to enhance image structures at locally appropriate scales.

### C. *Feature extraction*

Image features at various levels of complexity are extracted from the image data. Typical examples of such features are

- Lines, edges and ridges.
- Localized interest points such as corners, blobs or points.

### D. *Detection/segmentation*

At some point in the processing a decision is made about which image points or regions of the image are relevant for further processing. Examples are

- Selection of a specific set of interest points
- Segmentation of one or multiple image regions which contain a specific object of interest.

### E. *High-level processing*

At this step the input is typically a small set of data, for example a set of points or an image region which is assumed to contain a specific object. The remaining processing deals with, for example:

- Verification that the data satisfy model-based and application specific assumptions.

- Estimation of application specific parameters, such as object poses or objects size.
- Classifying a detected object into different categories.

## IV. CONCLUSION

In today's digitized world, processing speeds have increased dramatically, with computers being advanced to the levels where they can assist humans in complex tasks. Yet, input technologies seem to cause a major bottleneck in performing some of the tasks, under-utilizing the available resources and restricting the expressiveness of application use. This paper has shown without any doubt that Connected Component can be used for image processing, as boundary detection is one of the more complicated image processing tasks – so this algorithm could be used for easier image processing techniques with very little effort.

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