Interaction with 3D Model through Hand Movements

Rachita S. Waghmare¹, Sushmita K. Ahire², Jueily S. Wayde³, Pranita K. Fuldeore⁴
¹(Computer Engineering, LGNSCOE Nashik, SavitribaiPhule Pune University, Maharashtra, India)
²,³,⁴(Computer Engineering, LGNSCOE Nashik, SavitribaiPhule Pune University, Maharashtra, India)

I. Literature Survey

The Shape based hand recognition system is the first live biometric based recognition system. That is dated in 1858, It is the first system to capture hand and finger images. Next system is date in mid 1960s by Robert Miller who invented a mechanical hand geometry identification device. To measure the finger length, the skin translucency, and the end point contours it uses the first commercial device used mechanically scanned photocell.

In 1986, recognition system presents the ID3D hand key device using low cost digital imaging sensors. The rising number of commercial systems demonstrates the advantage of this approach, with many approaches proposed. The hand geometric features are utilized by the hand geometry systems, such as, finger widths, palm areas, finger lengths, measure ratios, etc. Hand geometry systems shorten the information given in hand instance to an N dimensional vector. This information is used to apply a matching algorithm based in a metric distance. Some optional methods are proposed in literature applying different probabilistic and machine learning techniques, like, Gaussian mixture model, k-Nearest neighbors or support vector machine.

Adan et al use a hand natural reference system. That facilitates to make the system robust against different hand poses, and the time averaged feature vector support classification. Webcam is used in this system. Sanchez-Reillo et al apply Gaussian mixture in which 25 features, such as, fingers widths, palm and finger heights, finger deviations and angles of the inter finger valleys with respect to the horizontal, modeling them. Yoruk et al uses 2048 points of contour coordinates to set up an independent component analysis features and raw feature vector that are used for identification and verification tasks.

Woodard et al utilizes shape indices based on 3D shape curvature to match correlation coefficients between shape descriptors. At the end, the palm silhouette lines for matching are used by palm print systems, which are frequently in combination with geometric measures.

Contactless hand recognition systems are getting attention because of their better user acceptability, and capability to be extended to daily devices. In the end, hand recognition using low cost devices is an important issue. Our system uses a contact free device that retrieves the palm parameters. It explores the identification information controlled in various geometric palm

Abstract:

The goal of this paper is to study the importance of contactless identification of hand gestures and to setting up the hands free communication environment in order to accomplish the functionalities of smart spaces. The solution provided by the system will depend on different hand movements captured by commercial 3D sensor. To achieve this task Leap Motion sensor is used. The classification of hand features is one of the important tasks to evaluate the hand gesture. Different classification strategies are available for classification of hand gestures which are nearest neighbour, support vector machine, MD-DTW (Multi-Dimensional Dynamic Time Warping), rule based system, Multilayer perceptron, tree algorithms and logistic regression. For each user, 52 morphological features are collected. These features are nothing but palm characteristics, length and width of bones, distance between fingers and finger valleys, distance between palm centre and wrist etc. The testing results showed that the leap motion controller is able to deliver accurate tracing of hands and fingers and also the movement of them. In order to achieve consistent samples and guarantee the best performance for controller, sweet spots are used to guide user to place the hand in best alignment with respect to controller.

Keywords— classification, contactless identification, smart spaces, 3D sensor, sweet spot.
features and different classifiers are used to show the feasibility of building an effective identification system.

II. Introduction

The goal of hand gesture recognition system is to sense the hand movements and execute the task according to the hand gesture. The hand gesture recognition system has to build interaction between controller and human for conveying meaningful information. The information will convey in the form of hand gesture which will results in appropriate action.

The hand gesture recognition system should be developed in such a way that it should be able to recognize and distinguish between different hand gestures over two dimensional and three dimensional planes.

A. Hand gesture recognition systems are classified in two ways

1) Recognition system over two dimensional planes: This type of systems deals with the 2D (i.e. 2 Dimensional) plane. 2D plane consists of X and Y axis. Position of hand is calculated by these two axis values. According to the hand position hand gestures are translated into actions.

2) Recognition system over three dimensional planes: This type of systems deals with 3D (i.e. 3 Dimensional) plane. In addition to X and Y axis, 3D plane consists of third dimension represented by Z axis. Z axis represents the depth of image. This type of systems also calculates hand position and hand gestures are translated into action.

There are different types sensors are available which deals with hand gestures in contactless way. One such type of sensor is Leap Motion sensor. Leap motion sensor senses hand gestures, captured information is processed by interface and finally it converts those processed information into actions.

Leap Motion controller is launched to market in 2013. It is specially designed to interact with different applications. Leap motion controller is nothing but a small peripheral device which is connected to the system through USB. This device allows hand and finger movements taken as an input in totally contactless manner with controller. Leap motion controller is equipped with two monochromatic infrared cameras and three infrared LEDs, which are used to generate 3D dot pattern of infrared light. This device has hand skeleton model. Leap motion controller detects the different features of hand such as hand and finger bone points which are used to track hand movements.

There are different application areas of leap motion controller; one of them is in education field in which leap motion enables user to view, control and access 3D illustration of molecules. For better view and understanding of shape and size of molecule; leap motion allows pan around the molecule. Leap motion controller also enables zoom in and out structure of molecules and chemical bonds of molecules to view the molecular structure in different angles. Important point to be noted here is that the operations on molecules such as zoom in and out, rotate and changing size are performed in totally contactless manner.

III. Algorithm

To implement the above system different strategies are used, one of them is Rule Based System. Rule based systems are used to store and handle knowledge to understand information in useful way.
A. To develop a rule-based system for a given problem, following tasks should be performed

1) To represent the initial working memory a set of facts are used. This should be related to the beginning state of the system.

2) Set of rules: this incorporates any and all actions that should be taken within the scope of a problem but nothing should be irrelevant. The number of rules in the system can affect the performance of a system.

3) A condition that governs a solution has been found or that none exists. It is essential to terminate some rule based systems that can be probably enters into infinite loops.

In rule based system, any rule comprises of two parts: the IF part, called antecedent (condition) and THEN part, called consequent (action or conclusion).

IF <antecedent>
THEN <consequent>

A rule can have multiple antecedent joined by the keywords AND (conjunction), OR (disjunction) or mixture of both.

IF <antecedent 1>
AND <antecedent 2>
. .
AND <antecedent n>
THEN <consequent>

IF <antecedent 1>
OR <antecedent 2>
. .
OR <antecedent n>
THEN <consequent>

For example:

IF traffic signal is “green”
THEN action is “go”
IF traffic signal is “red”
THEN action is “stop”

The antecedent of rule comprises of two parts: an Object (Linguistic Object) and its Value. The object is linked with its value with the help of an operator. The operator identifies the object and assigns the value. The symbolic value is assign to a linguistic object using operators such as is, are, is not and are not etc. To define an object as numerical and to assign numeric value to it, rule based system make use of mathematical operators. For example:

IF ‘age of customer’ < 18
AND ‘cash withdrawal’ > 1000
THEN ‘signature of parent’ is required

B. Rules can also represent relations, recommendations, directives, strategies and heuristics

1) Relations:

IF ‘the fuel tank is empty’
THEN ‘car is dead’

2) Recommendations:

IF ‘the season is autumn’
AND ‘the sky is cloudy’
AND ‘the forecast is drizzle’
THEN ‘the advice is take an umbrella’

3) Directive:

IF ‘the car is dead’
AND ‘the fuel tank is empty’
THEN ‘the action is refuel the car’

4) Strategy:

IF ‘the car is dead’
THEN ‘the action is checking the fuel tank’
Step1 is complete
IF ‘step1 is complete’
AND ‘the fuel tank is full’
THEN ‘the action is check the battery’
Step2 is complete

5) Heuristic:

IF ‘the spill is liquid’
AND ‘the spill pH < 6’
AND ‘the spill smell is vinegar’
THEN ‘the spill material is acetic acid’

Rule based system uses a simple technique. It begins with a rule base, which consists of knowledge encoded in the form of if-then rules, and a working memory, in which initially may or may not consists of any data, assertions or initially known information. The system inspects all the rule conditions (IF) and determines a subset and the conflict set of rules whose conditions are satisfied based on working memory. From this conflict set, one of those rules is fired. Conflict resolution strategy decides which rule to trigger. When rule is triggered, actions specified in its THEN clause are executed. These actions can modify working memory, the rule base itself or do just anything else that system programmer wants to include. This loop of triggering rules and performing actions continues until one of two conditions is encountered: a rule is fired whose action specifies the program should terminate or there are no more rules whose conditions are satisfied.
C. Architecture of rule based system

The architecture of rule based system consists of following modules.

1) Knowledge Base: Knowledge base consists of facts and rules about some particular knowledge domain. This allows user to enter knowledge in the system by avoiding need of knowledge engineer explicitly code the knowledge. Simple rules are created using rule induction. In rule based systems, knowledge base is also called production memory as rules in the form of if-then are called productions.

2) Inference Process: This module takes user input query and response to question through I/O interfaces. It selects which rules are fulfilled by the facts, ranks them, and executes the rule with highest priority. There are two types of inference: forward chaining and backward chaining. Backward chaining maps hypothesis to the facts that support this hypothesis while forward chaining is reasoning which maps facts to the conclusion while. Whether an inference engine performs forward chaining or backward chaining totally depends on the design which in turn depends on the type of problem.

This process is carried out in three stages: Match: In this phase, contents of working memory are compared against the left hand sides of all productions. As a result a conflict set is achieved, which comprises of instantiations of all fulfilled productions. An instantiation of a production is an ordered list of working memory elements that fulfills the left hand side of the production. Conflict-Resolution: In this phase, for execution, one of the production instantiation in the conflict set is selected. The interpreter halts if no productions are satisfied. Act: In this phase, the actions of the production selected in the conflict resolution phase are executed. Contents of working memory may be changed by these actions. Execution returns to the first phase at the end of this phase.

3) Explanation Module: This module delivers the user with an explanation of reasoning procedure when demanded. This is done in response to HOW and WHY query. It explains the user about the reasoning process of the system. By keeping track of rules that are fired, an explanation capability presents a chain of reasoning that headed to a certain conclusion. That’s why explanation facility is also called as justifier.

4) I/O inference: The I/O inference allows the user to communicate with system in more natural way by allowing the use of simple selection menus or the use of controlled language.

5) Working Memory: Working memory is a database which is used to store pool of facts which will in future be used by the rules. More efforts should go into design and implementation of the user interface rather than in the expert system knowledge base. Inference engine uses working memory to get facts and match them against the rules. By applying some rules, facts may be added to working memory.

IV. System Architecture

From the earliest hardware models to the latest tracking software, the Leap Motion platform has come a long way. The leap motion controller consists of two cameras and three infrared LEDs. Firstly, the device’s USB controller interprets the sensor data into its own local memory and performs some necessary resolution adjustments. This data is then move via USB to the Leap Motion tracking software. After the image data is streamed to your computer, it’s time for some massive mathematical calculation. The Leap Motion Controller doesn’t generate a depth map; else it applies advanced algorithms to the raw sensor data.

Here in our system we are applying Rules based algorithm. Ruled based algorithm is applied in for feature extraction. This algorithm introduces new measures for generating and optimizing rules. These new measures are calculated with respect to uncertain data interval and probability distribution function. Supported by the new measures, the best splitting attribute and splitting value can be identified and used.
for classification and reasoning. This algorithm uses the ordered covering progress to extract rules from the data. The algorithm takes out the rules one class at a time for a data set. Algorithm will extract the set of rules that shows the relationship between attributes of the dataset. A rule $R$ covers an instance if the attributes of the instance fulfill the condition of the rule.

The Proposed System works in three steps that is hand tracking, feature extraction, training, and gesture recognition.

First, we present a real time hand gesture tracking technique which can observe the moving hand and then extract the hand shape from background. It is a simple and reliable technique developed as a real-time image processing subsystem which contains some basic complementary image processes: motion detection, feature extraction, edge detection, and movement justification.

Segmentation process is the initial process for recognizing hand gestures. It is the process of splitting the input image (hand gesture image) into regions distributed by boundaries. The segmentation procedure is depend on the type of gesture, if it is dynamic gesture then it required that the hand gesture should located and tracked, if it is static gesture the input image has to be divided only.

Good segmentation process cause to perfect features extraction process and the play an important role in a successful recognition procedure. Features vector of the divided image can be extracted in different ways as per the specific application. Various methods have been used for representing the features and can be extracted. Some techniques used the shape of the hand such as silhouette and hand contour while others uses fingertips position, palm centre, etc.

After modelling and analysis phase of the input hand image, gesture classification technique is used to recognize the gesture. Recognition process impressed with the appropriate selection of features parameters and well suited classification algorithm. For example contour operators or edge detection cannot be utilized for gesture recognition since numerous hand postures are generated and could make misclassification. To classify the gestures Euclidean distance metric is used.

V. Leap Motion Controller

The Leap Motion Sensor is a device that aims to translate hand movements into computer commands. The Sensor is an eight by three centimetre unit that plugs into the USB on a computer. The Leap Motion Controller placed face up on a surface; it senses the area above it. The Controller is sensitive to a range of approximately one meter. The controller was released in 2013, and it presents the opportunity for a new way of interacting with 3D Models.

The Leap Motion Controller is a small USB peripheral device which is designed in such a way that it can be placed on physical desktop, facing upward. The Sensor has two Monochromatic Infrared cameras and three infrared LED’s, the device detects a roughly hemispherical area. The LED’s generate pattern less IR light and the cameras create almost 300 frames per second of reflected data, which in turn sent through a USB cable to host computer, it is then analysed by the Leap Motion Sensor software using “complex math’s” in such a way that has not been disclosed by the company.

The sensor can sense up to 200 frames per second. Every frame sends information about the hands by comparing the IR scenes against an internal hand model. The model defines that each hand has five fingers formed by four bones except for the thumb, which is formed by three (proximal, intermediate and distal phalanx). API provided by Leap Motion controller, which can recognize hands, fingers, arms, and tools (straight cylindrical objects longer and with a smaller
radius fingers) over it. These libraries also allow recognizing four predefined gestures (swipe, key tap, screen tap and circle), provide the image acquired by the two cameras and discern between the two hands that the user may be using.

Fig.4. Leap Motion Controller

Application of Leap motion sensor in Education allows us to view and manipulate 3D renderings of molecules. The interface is collected to provide real time indications for the user to put the hand at 18-21 cm on the Leap Motion device(y axis), in the middle of it(x axis) and slightly advanced with respect to the device (Z axis between -3 and 7cm). This pose guarantees the best vision of the hand, as the most accurate measurements are obtained when the hand is between 12 and 25cm and in the negative values of the z axis 27. The indications to the user are shown by red tags that are activated in case the hand is not in the perfect position. The tags indicate the user in which direction to move the hand.

Plug the Leap Motion controller into a USB port and then the controller either in front of the Keyboard for a laptop or in between the screen and keyboard for desktop computer. Then, download the software of Leap Motion from website. The software then shows an instant introduction about how the controller tracks all ten fingers and the space above the device.

Using sensor motion control technology, Leap Motion Sensor is set to replace other conventional methods of interaction like mouse, keyboard and so on. By removing the computer mouse, it uses more desktop space. As the controller is small, you are able to place it right in front of your keyboard and leave the rest of space surrounding your keyboard open. The sensor does not need any form of touching or any other analogous method. Leap Motion Controller is more secure and precise. As it is highly accurate and efficient, leap Motion technology has wide applications in many fields like airspace, consumer sector, Entertainment etc. The Leap Motion launches world’s most accurate 3D motion control technology for computing. Sensor magic bubble gives you pc control with wave of hand.

VI. Result Analysis

Previous systems were contact based systems, we can overcome this drawback then we are created totally contact free system. By using leap motion technology we can find the hand gestures. To recognize the gesticulation some classification algorithm can use such as nearest neighbour algorithm, multilayered perceptron algorithm, and MD-DTW algorithm.

A. K-Nearest Neighbor Algorithm

Nearest neighbour is nothing but the instance based learning algorithm. It is the part of supervised learning classifications in data mining, image processing, statistical pattern recognition system. Nearest neighbour can find the closer element to each other. It has the very robust algorithm to noisy training data. It has the more effective because training data can be large. Every technique has some advantages as well as drawbacks; nearest neighbour also contain some drawbacks such as to produce best result it needs to determine the value of constraint. It also needs to determine which type of attribute and distance to use, but this technique is not able to determine it correctly. Computation cost can be high because we need to compute the distance to all training data.

B. MD-DTW(Multi-Dimensional-Dynamic Time Warping)

MD-DTW can use multidimensional series for calculating the dimensions. In that multiple features are extracted in multiple instances. In this algorithm multiple measurements are made simultaneously.

To find the gestures or hand movements rule based algorithm can be used. It specifies some rules which describe actions should perform or not? Which finger to be detected? Positions of hand are correct or not? Distance of the finger is accurate or not? All these actions can be set by using rule based algorithm.
C. Rule Based System

Rule base is specific type of knowledge based system. It is based on interaction with input gestures. The interpreter can execute production system program by using some rules. Rule based system contains various advantages such as natural knowledge representation, uniform structure. Separation of knowledge from its processing and dealing with incomplete and uncertain knowledge. Rule based algorithm is classification algorithm. In that, various classification techniques are used such as PART, Decision Tree, RIPPER, RIDOR.

1) PART: It is the Partial Decision Tree technique for constructing classification rules. It employs the first generate the tree. After generation of tree rules are derived directly from partial tree starting with the deepest leaf node. Then, partial decision tree can be removed.

2) RIPPER: The Repeated Incremental Pruning to Produce Error Reduction. It can be more efficient than decision tree on large data sets. It contains the four phases such as, Growth, Pruning, Optimization and Selection. In Growth phase, it can produce the sequences of individual rules by adding predicates until the rule satisfies stopping criteria. In Pruning step, the rules that reduce the performance of algorithm are pruned. In Optimization phase, each rule is optimized by adding attributes to original rule or generates new rule by using Growth and Pruning phase. In last phase, best rules are retained and others rules are ignored from the model.

3) RIDOR: It is the Ripple Down Rule learner classifier technique. It constructs the default rule and then produces the exceptions for the default rule with lowest error rate. It produces tree like expansions of exceptions.

4) Decision Tree: It is the Flow-chart like tree structure. It is generated by recursive divide-conquer algorithm. In that, every internal node indicates test on an attribute and each branch specifies the results of the test and each leaf node contains related target class.

D. Performance Analysis

To compare the performance of PART, RIPPER, RIDOR and Decision Tree classifiers these criteria can be used: Classifications Accuracy, Number of relations, Number of attributes, Number of tuples and Number of foreign-keys. When generating the database three parameters can constructed such as number of relations, number of tuples in each relation, and number of foreign-keys in each relation. We can utilize the Rx, Ty, Fz. Where Rx represents the number of relations, Ty represents the number of tuples and Fz represents the number of foreign-keys. In that, runtime and accuracy are compared and calculated on it.

1) To access the scalability with respect to number of relations: we can create four databases with 10, 15, 20 and 25. In each relation the expected numbers of tuples are 1000 and expected number of foreign keys is 2. Then calculates the runtime and accuracy of relations are shown in following fig.
2) To estimate scalability with respect to number of tuples: We can create five databases 1000, 3000, 5000, 7000 and 10000. In that number of relations are 10 and number of foreign keys are 2. Then, calculate the runtime and accuracy are shown in following figure.

3) To test the scalability with respect to foreign keys: we can create three databases with 1, 2 and 3 respectively. In that expected number of tuples are 1000 and numbers of relations are 10. Then, calculate the runtime and accuracy with respect to foreign keys is shown in following figure.

VII. Conclusion

The contact based system researched various classification techniques and algorithms. These classification algorithms can describe the real-time system. Real-time system can be in-air hand shape identification system to be interaction with some smart applications. With the help of Leap Motion technology it has been possible to compare the hand features and it can be translated into actions.

Acknowledgement
We would like to take this opportunity to express our profound gratitude and deep regard to our project guide Prof. Mr. Prashant A Kale for his valuable feedback and constant encouragement throughout the duration of process of writing paper. His valuable suggestions were of immense help throughout our paper work. Working under him was an extremely knowledgeable experience for us.

References


