A

Seminar report

On

Humanoid Robot

Submitted in partial fulfillment of the requirement for the award of
Degree of Mechanical

SUBMITTED TO: SUBMITTED BY:

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Preface

I have made this report file on the topic **Humanoid Robot**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to …………..who assisting me throughout the prepration of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

Acknowledgement

I would like to thank respected Mr…….. and Mr. ……..for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

Thirdly, I would like to thank my friends who helped me to make my work more organized and well-stacked till the end.

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Last but clearly not the least,I would thank The Almighty for giving me strength to complete my report on time.

Content

CHAPTER 1

ROLE OF HUMANOIDS

1.1 INTRODUCTION:

The field of humanoids robotics, widely recognized as the current challenge for robotics research, is attracting the interest of many research groups worldwide. Important efforts have been devoted to the objective of developing humanoids and impressive results have been produced, from the technological point of view, especially for the problem of biped walking.

In Japan, important humanoid projects, started in the last decade, have been carried on by the Waseda University and by Honda Motor Co.

The Humanoid Project of the Waseda University, started in 1992, is a joint project of industry, government and academia, aiming at developing robots which support humans in the field of health care and industry during their life and that share with human information and behavioral space, so that particular attention have been posed to the problem of human-computer interaction. Within the Humanoid Project, the Waseda University developed three humanoid robots, as research platforms, namely Hadaly 2,Wabian and Wendy.

Impressive results have been also obtained by Honda Motor Co. Ltd with P2 and P3, self-contained humanoid robots with two arms and two legs, able to walk, to turn while walking, to climb up and down stairs. These laboratories on their humanoid robots carry on studies on human-robot interaction, on human-like movements and behavior and on brain mechanics of human cognition and sensory-motor learning.

Developing humanoids poses fascinating problems in the realization of manipulation capability, which is still one of most complex problem in robotics. For its scientific content and for its utility in the most robotics applications, the problem of manipulation has been deeply investigated and many results are already available, both as hands and sensors and as control schemes.

The Hitachi Ltd. Hand has proposed an approach in designing robotics hands with its radial space memory alloy (SMA) metal actuation technology. The hand is characterized by a high power-to-weight ratio and a high compactness. The Hitachi Hand uses a large number of thin SMA wires; each finger has 0.02mm diameter SMA wires that are set around the tube housing of the spring actuators. The SMA wire, when heated by passing electric current through it, reacts by contracting against the force of the spring.

The development of a robotic hand for space operations is currently ongoing also in the Robotic Systems Technology Branch at the NASA Johnson Space Center. The Robonaut Hand has a total of fourteen degrees of freedom and consists of a forearm, which houses the motors and drive electronics a two-degree of freedom wrist, and five-fingers, twelve degrees of freedom, hand. The hand itself is divided into sections: a dextrous work set which is used for manipulation and grasping set which allows the hand to maintain stable grasp while manipulating or actuating a given object.

The main goal is to manufacture human-like hands, whose main requirements are cosmetics, noiselessness and low weight and size. Myoelectrically controlled prostheses are at present the best way to partially restore the functionality of an amputated limb. Finally hybrid prostheses combine a body-powered with a myoelectric prosthesis in case of shoulder disarticulation level amputations.

The proposed approach to the design and development of humanoid robots relies on the integration of humanoid components intended both as anthropomorphic hardware systems, and as software modules implementing anthropomorphic control and behavioral schemes.

1.2 THE BIOMECHATRONIC APPROACH FOR THE DEVELOPMENT OF ARTIFICIAL HANDS.:

The main goal in designing a novel humanoid hands is to fulfill critical requirements such as functionality, controllability, low weight, low energy consumption and noiseless. These requirements can be fulfilled by an integrated design approach called biomechatronic design.

The first step towards this objective is to enhance the hand dexterity by increasing the DOF and reducing size of the system. The main problem in developing such a hand is the limited space available to integrate actuators within the hand. Anyway, recent progress in sensors, actuators and embedded control technologies are encouraging the development of such hand.

1.2.1 SYSTEM ARCHITECTURE:

The proposed biomechatronic hand will be equipped with three actuators systems to provide a tripod grasping: two identical finger actuators systems and one thumb actuator system.

The finger actuator system is based on two micro actuators which drive respectively the metacarpo-phalangeal joint (MP) and the proximal inter-phalangeal joint (PIP); for cosmetic reasons, both actuators are fully integrated in the hand structure: the first in the palm and the second within the proximal phalanx. The distal inter-phalangeal (DIP) joint is driven by a four bar link connected to the PIP joint.

The grasping task is divided in two subsequent phases:

1> Reaching and shape adapting phase;

2> Grasping phase with thumb opposition.

In fact, in phase one the first actuator system allows the finger to adapt to the morphological characteristics of the grasped object by means of a low output torque motor. In phase two, the thumb actuator system provides a power opposition useful to manage critical grips, especially in case of heavy or slippery objects.

1.2.2 KINEMATIC ARCHITECTURE:

A first analysis based on the kinematics characteristics of the human hand, during grasping tasks, led us to approach the mechanical design with a multi-DOF hand structure. Index and middle finger are equipped with active DOF respectively in the MP and in the PIP joints, while the DIP joint is actuated by one driven passive DOF.

The thumb movements are accomplished with two active DOF in the MP joint and one driven passive DOF in the IP joint. This configuration will permit to oppose the thumb to each finger.

1.3 ANTHROPOMORPHIC SENSORY-MOTOR CO-ORDINATION SCHEMES:

A general framework for artificial perception and sensory-motor co-ordination in robotic grasping has been proposed at the ARTS LAB, based on the integration of visual and tactile perception, processed through anthropomorphic schemes for control, behavioral planning and learning. The problem of grasping has been sub-divided into four key problems, for which specific solutions have been implemented and validated through experimental trials, relying on anthropomorphic sensors and actuators, such as an integrated fingertip (including a tactile, a thermal and a dynamic sensor), a retina-like visual sensor, and the anthropomorphic Dexter arm and Marcus hand. (See Figure 3)

Figure 3: The Marcus Hand with the integrated fingertip And the Dexter Arm

In particular,

1. Planning of the pre-grasping hand shaping,
2. Learning of motor co-ordination strategies.
3. Tactile-motor co-ordination in graspind and
4. Object classification based on the visuo-tactile information are described and reported in the following paragraphs.

1.3.1 A NEURO-FUZZY APPROACH TO GRASP PLANNING:

The first module has the aim of providing the capability of planning the proper hand, in the case of a multi-fingered hand, based on geometrical features of the object to be grasped. A neuro-fuzzy approach is adopted for trying to replicate human capability of processing qualitative data and of learning.

The base of knowledge on which the fuzzy system can process inputs and determine outputs is built by a neural network (NN). The trained system has been validated on a test set of 200 rules, of which the 92.15% was correctly identified.

1.3.2 INTEGRATION OF VISION AND TOUCH IN EDGE TRACKING:

In order to validate the anthropomorphic model of sensory-motor co-ordination in grasping, a module was implemented to perform visual and tactile edge tracking, considered as the first step of sensory-motor co-ordination in grasping actions.

The proposed methodology includes the application of the reinforcement-learning paradigm to back propagation NNs, in order to replicate the human capability of creating associations between sensory data and motor schemes, based on the results of attempts to perform movements. The resulting robot behavior consists in co-ordinating the movement of the fingertip along an object edge, by integrating visual information on the edge, proprioceptive information on the arm configuration, and tactile information on the contact, and by processing this information in a neural framework based on the reinforcement-learning paradigm. The aimed goal of edge tracking is pursued by a strategy starting from a totally random policy and evolving via rewards and punishments

CHAPTER 2

REAL-TIME FACIAL GESTURE RECOGNITION SYSTEM

2.1 INTRODUCTION:

Gestures are an important form of communication between people. We regard expressions of the face as one of the most natural forms of human expression and communication. People who are elderly, disabled or just inexperienced users of computer technology a gesture interface would open the door to many applications ranging from the control of machines to "helping hands". The crucial aspect of a gesture interface is not only real-time performance, but also the ability to operate robustly in difficult real world environments.

To understand human gestures based on head movement a system must be capable of tracking facial features in real-time. We consider real time to be NTSC video frame rate (30Hz). If facial tracking is done at lower rates then it is very difficult to understand gestures.

The real-time facial gesture recognition system consists of two modules running in parallel; a Face Tracker and a Gesture Recognizer. The face-tracking module fuses information from the vision system with information derived from a two-dimensional model of the face using multiple Kalman filters. We use dedicated hardware, which tracks features in real-time using template matching. Relying solely on such dedicated hardware it is not possible to reliably and robustly track a human face since under normal lighting conditions the shape and shading of facial features will change markedly when the head moves. This results in a failure by the vision hardware to correctly match the changing templates. Kalman filters are used to solve this problem that uses data from the tracking system with a geometrical model of the face. A face tracker is built that operates under natural lighting without artificial artifacts. The system is robust and runs at video frame rate. Reliable and rapid tracking of the face gives rise to ability to recognize gestures of the head. A gesture consists of a chain of atomic actions, where each atomic action represents a basic head motion. e.g.: upwards or to the right etc. The "yes" gesture is represented the atomic action chain of "move up","stop","move down", etc. if an observer reaches the end of a chain of atomic actions then a gesture is deemed to have been recognized. We use a probabilistic approach to decide if an atomic action has been triggered. This is necessary since it is rare for identical actions to be exactly the same e.g.: nobody nods in the same way every time.

2.2 THE VISION SYSTEM:

The use of MEP tracking system is made to implement the facial gesture interface. This vision system is manufactured by Fujitsu and is designed to track in real time multiple templates in frames of a NTSC video stream. It consists of two VME-bus cards, a video module and tracking module, which can track up to 100 templates simultaneously at video frame rate (30Hz for NTSC).

The tracking of objects is based on template (8x8 or 16x16 pixels) comparison in a specified search area. The video module digitizes the video input stream and stores the digital images into dedicated video RAM. The tracking module also accesses this RAM. The tracking module compares the digitized frame with the tracking templates within the bounds of the search windows. This comparison is done by using a cross correlation which sums the absolute difference between corresponding pixels of the template and the frame. The result of this calculation is called the distortion and measures the similarity of the two comparison images. Low distortions indicate a good match while high distortions result when the two images are quite different.

To track a template of an object it is necessary to calculate the distortion not only at one point in the image but at a number of points within the search window. To track the movement of an object the tracking module finds the position in the image frame where the template matches with the lowest distortion. A vector to the origin of the lowest distortion represents the motion. By moving the search window along the axis of the motion vector objects can be easily tracked. The tracking module performs up to 256 cross correlations per template within a search window.

The MEP tracking vision system works perfectly for objects that do not change their appearance, shade and are never occluded by other objects. When the vision system is used to track a face in a head and shoulder image of a person then problems arise because the head occupies most of the image, one template of the entire face exceeds the maximum template size allowable in the vision system. Therefore, it is only possible to track individual features of the face such as the eyes or mouth. The facial features with high contrast are good candidates as tracking templates. For e.g.: an eyebrow which appears to be a dark stripe on a light background (light skin) and the iris of the eye which appears as dark spot surrounded by the white of the eye are well suited for tracking.

These problems are further complicated by the fact that well suited tracking features can change their appearance dramatically when a person moves their head. The shading of the features can change due to uneven illumination and the features appear to deform when the head is turned, moved up, down or tilted to the side. All these changes increase the distortion even if a template is matching precisely at the correct position. It also results in low distortions at the wrong coordinates, which then cause the search window to be incorrectly moved away from the feature. This problem arises when a head is turned sufficiently far enough for one half of the face with all its associated features to completely disappear. Once the tracking feature has left the search window the movement vectors calculated by the vision system are unpredictable. There is a method developed to allow a search window to correctly find its lost feature thus yielding a reliable face tracker.

2.3 TRACKING THE FACE:

Our basic idea is that individual search windows help each other to track their features. From the known geometric relationship between the features in a face, a lost search window can be repositioned with help from features that are still tracking. We use a two-dimensional model of the face in which features for tracking are joined to form a small network. The reference vectors connecting the features are derived from a single image automatically by the system or by a human operator. Figure 1 shows a face with boxes marking the nine (9) tracking features. We use the iris, the corners of the eyes, the eyebrows and the middle and corners of the mouth. The sizes of the boxes shown are the actual template sizes (16x16 pixels). The line connections shown in the figure indicate which features assist the other features for readjusting the search windows. We also use several templates to track features that can change their appearance. For example the eyes can be open or closed. In such cases we use three (3) templates for the different states (opened, closed and half-open-closed) of the eyes simultaneously. This makes it possible to determine the state of the tracking features e.g. an eye is open or the mouth is closed.

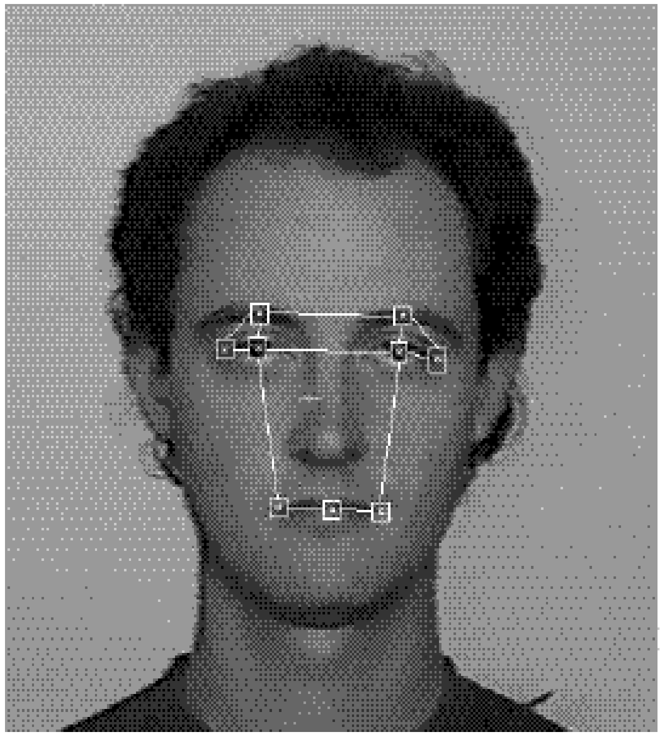

Figure 1: Facial Tracking Features

As discussed earlier if a person turns their head the distortions of all the templates increases greatly. In this situation some features may disappear and others may change their shade and appearance. It is difficult to determine whether search windows are tracking correctly or incorrectly. Lost search windows influence the tracking position of the other search windows. A situation can easily arise in which the system will loose the entire face. Simple thresholding of the distortion is insufficient to distinguish the lost windows from the tracking ones. An approach that can cope with noisy data is needed. Kalman filters were used solve this problem.

The Kalman filter is a recursive linear estimator, which merges the measurement of sensors observing the environment with a prediction that is derived from a system model. The Kalman filter is used in many applications such as navigation of planes, missiles and mobile robots where uncertain measurements from sensors that observe landmarks are used to localize a vehicle. By merging sensor information, the Kalman filter guarantees an optimal estimate of the sensor data in terms of a minimum mean-square error if an appropriate system model is used. All sensor data has co variances associated with it, which indicate the reliability of the data. The output of the filter also has a covariance, so the control system does not only obtain an estimate, but it also knows the reliability of the estimate.

Using Kalman filtering yields a system, which copes with head rotations of about 30 degrees during facing tracking. Further robustness was added to the face tracking by implementing dynamic search regions, which look for a feature inside a specific area of the image. The size of the search region is dependent on the variance of the features (determined from the Kalman filter). We also extended our 2D model of the face to allow for tilting. This extra technique allow the head to be rotated up to 60 degrees, tilted acutely from side to side, and enables quick recovery even when all the tracking features have been lost.

Figure 2: Tracking the face

Figure 2 shows four (4) images taken from a tracking sequence. The predicted estimates of the tracking features are marked with small white crosses.

Another improvement considered is to grab templates of the features dynamically while the system is tracking the face. This would not only improve the tracking, but the system would also cope with much greater ranges of changing illumination. It is planned to create a dynamic face model that adapts to the gathered data. Such a dynamic system would learn how to track the face of an unknown person. The system would be initially provided with several generic faces including startup templates and face geometries. It selects the most similar model for the unknown person and then learns the exact templates and geometry.

The figure 3 represents some of the recognizable facial gestures that are commonly used in our daily day-to-day life

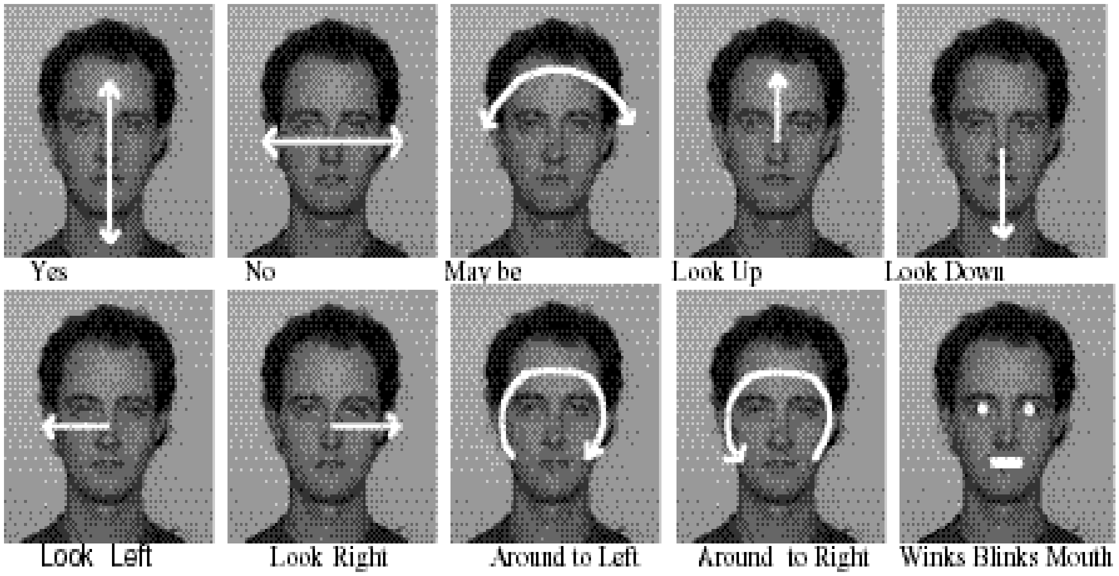

Figure 3: Recognizable Gestures

A gesture recognition module is implemented which runs in parallel with the face-tracking module at video frame rate (30Hz). This approach adopted produces reliable results and is robust to noise. The system accurately discriminates between 13 different gestures. Even though some gestures are quite similar to each other.

CHAPTER 3

CONCLUSION

The humanoid research is an approach to understand and realize flexible complex interactions between robots, environment and humans.

A humanoid robot is an ideal tool for the robotics research; First of all it introduces complex interactions due to its complex structure. It can be involved in various physical dynamics by just changing its posture without need for a different experimental platform. This promotes a unified approach to handling different dynamics. Since it resembles humans, we can start by applying our intuitive strategy and investigate why it works or not. Moreover, it motivates social interactions such as gestural communication or cooperative tasks in the same context as the physical dynamics. This is essential for three-term interaction, which aims at fusing physical and social interaction at fundamental levels.

Integrating human body components such as human prostheses for upper limbs, and anthropomorphic control and behavioral schemes can approach the humanoid robotics.

The Gesture Recognizer module that runs in parallel with the face-tracking module is capable of recognizing a wide variety of gestures based on head movements. Gesture recognition is robust due to the statistical approach we have adopted. In future the plan is to record and analyze the head gestures of a large sample of people. The plan is also to explore the prospect of allowing the machines to learn gestures based on observation.

The ultimate aim is to use the facial gesture recognition system in a robotic system for the disabled. The interface will allow disabled persons to feed themselves by using facial gestures to communicate with the helping robot.

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