Chapter 13

Conclusions

Much research has been accomplished to detect and track objects of interest acquired by humanoid vision system. Cues such as color, disparities, optical flow and 2-D shape have been used to implement real-time active vision systems. Researchers have typically studied behaviors such as visual attention, vestibulo-ocular reflexes, saccadic movements, smooth pursuit and mimicking of human movements. A modern tendency is the development of systems well-known as "biologically inspired" where are considered techniques and subsystems that try to reproduce the operation of active vision systems that are in the nature. Although there are many works of active vision systems in humanoids few use the flexibility of the intelligent techniques for their construction.

In robotic vision applications based on color-segmentation there is a common problem: the sensitivity to changes in the intensity of light. This is a result of the inability of some algorithms to tolerate variations presented in the color hue which correspond, in fact, to the same object.

Learning Vector Quantization (LVQ) networks learn to recognize groups of similar input vectors in such a way that neurons physically near to each other in the neuron layer respond to similar input vectors. In this thesis a new color-segmentation algorithm based on LVQ was presented. It involves neural networks that operate directly on the image pixels with a decision function. This algorithm has been applied to spotting and tracking human faces, and shows more robustness than other algorithms for the same task.

In this thesis we proposed the Fuzzy C-Means algorithm for the segmentation of not trivial-color objects using as a membership criteria to a cluster the Mahalanobis distance. This distance criteria consider also the clusters distribution and have a better results compared with an simple Euclidian distance criteria clasificator.

Real time visual tracking is a complicated problem due the different dynamic of the objects involved in the process. On one hand the algorithms for image processing usually consume a lot of time and on the other hand the motors and mechanisms used for the camera movements are significantly slow.

This thesis described the use of ANFIS model to reduce the delays effects in the control for visual tracking and also explains how we resolved this problem by predicting the target movement using a neurofuzzy approach. This prediction mechanism in tracking module made the tracking more stable.

In the robotics area, visual tracking is an important and difficult problem therefore it is necessary to have a robust and efficient control algorithm which presents immunity characteristics to stochastic direction and speed changes of the object to be tracked. For this work we used two fuzzy condensed algorithms running in a PC to control a robot's head which tracks a human face. The fuzzy condensed controller showed a better performance compared to the PID controller.

The Kalman filter has been used successfully in different tracking applications. Different movement conditions and occlusions can hinder the vision tracking of an object. In this thesis we consider the capacity of the Kalman filter to allow small occlusions and also the use of the extended Kalman filter (EKF) to model complex movements of objects.

The extended Kalman filter (EKF) has been used as the standard technique for performing recursive nonlinear estimation in vision tracking. In this thesis, we present an alternative filter with performance superior to that of the EKF. This algorithm, referred to as the Particle filter. Particle filtering was originally developed to track objects in clutter (multi-modal distribution). We present as results the filter behavior when exist objects with similar characteristic to the object to track.

The object tracking is one of the most important tasks in robots that allows to work necessarily with its environment. The stereo object tracking has the same objective that the monocular object tracking with the exception that in this case is also calculated the object depth. To guarantee the tracking of some object, it is necessary that the controller which moves the motors of the vision system acts in intervals smaller to the time constant of the movements of the tracked object. In this thesis we present a solution to the object tracking problem with depth measurement that allows under delay conditions to have a good performance in real time.

This thesis presents a stereo active vision system that are designed for a humanoid robot. The task was decomposed into four layers as object localization, tracking, control and depth measurement. We adopted the developmental approach, which is based on intelligent techniques, for the robot vision. Neural networks and Fuzzy algorithms are used for the object localization. For tracking, searching most similar region approaches (Camshift and Particle filter) were utilized. A neuro-fuzzy prediction mechanism in tracking module made the tracking more stable. The stereo active vision system was controlled using adaptive and fuzzy algorithms which modify their behavior depending on the movements carried out by the tracked object. For the depth determination, we used a simple correspondence procedure based in a epipolar assumption. As a result of the combination of these modules and techniques, the system demonstrated real time tracking, velocity, and robust control.