APPROVAL

" I hereby declare that I have read through this report entitle Detection of Anomaly Object by Using Humanoid Robot and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronic Engineering".

Signature : …..……..

Supervisor's Name : …….……...

Date : …….……..…….

DETECTION OF ANOMALY OBJECT BY USING HUMANOID ROBOT

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A report submitted in partial fulfillment of the requirements for the degree of Mechatronics Engineering

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2016

DECLARATION

I declare that this report entitle “Detection of Anomaly Object by Using Humanoid Robot” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : …..…….

Name : …….…….

Date : …….……..……

DEDICATION

To my beloved family

ACKNOWLEDGEMENT

First and foremost, I would like to take this opportunity to express my sincere appreciation to my supervisor En. Mohd Bazli bin Bahar from Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka (UTeM) for his supervision, encouragement, guidance critics and support towards the completion of this whole Final Year Project. It is so glad to have the opportunity and essence to do researches and field study for my Final Year Project (FYP) that entitle Detection of Anomaly Object by Using Humanoid Robot.

In addition, special thanks to all lecturers of Mechatronics Department for the knowledge and information throughout 4 years of my journey as a student. I am very grateful with their effort, motivation and attention during the learning process. Without them, I would never manage to develop the idea for this project and make the project to be realized.

Last but not least, deepest gratitude to my family, fellow course mates and acquaintances for the mental support and assistance during thick and thin of my days to complete this project. I am really thankful to everyone for helping me in various occasions. By doing this project, it giving a cherished moment to me as this is the first project that I need to work by myself.

ABSTRACT

On the way to identify the anomaly behaviour, the main issues are object detection, position and the algorithm on how to point out the target that being digress from the normal situation. Many researches out there are about the anomalies in video surveillance in a crowd scene but there is least about the abnormal object in a frame with considering the various position and different object size. Thus, this project introduced a technique for a humanoid robot to detect and learn the representations of objects within a control environment but at the same time detecting the anomalies pattern that may happen when the object is partially placed out from the respective frame and the size limitation of object from the smallest until the biggest size. It involves the application of vision system to computes the shape, body colour and pixels values to accurately identify the location and pattern of anomalies. Altered scenario in series of experiments are when another frames are put next to the current center frame, different position of object and object size are unlikely similar in every frame. Briefly, all variables and the performances of the experiment will be observed and tabulated. The project have been showcased by using robotic platform software to test the performances of the anomalies and normal form in different situation. With four different experiments, the anomaly condition and normal condition can be proved and distinguished. The actual location of anomaly in one frame can be located using mathematical formulae too. By mean of that, the mean value for anomaly is decreasing about 50% from the normal frame and majority of the values for standard deviation are twofold from the common condition when the size of object is manipulated. The limitation for object size is starting from 0.4x0.4 cm until 50x50 cm. While, the mean values had minor difference about 0.01-0.04 from the normal one and the deviation values are fluctuated by way the effects of object position proposed into the system. The deviation value when the object is located between two frames are remarkably the lowest compared to the value when full object is totally in a frame.

ABSTRAK

Dalam mengenalpasti keadaan yang anomali, beberapa isu utama iaitu pengesahan objek, pengenalpastian objek dan algoritma digunakan untuk menunjukkan sesuatu objek itu berlainan daripada situasi yang normal. Kebanyakan daripada kajian umum adalah untuk mengkaji anomali di dalam video keselamatan dalam situasi orang ramai. Bagaimanapun, kajian mengenai objek anomali di dalam satu bingkai dengan mengambil kira kedudukan objek dan saiz objek yang berlainan adalah amat sedikit. Jika adapun, ianya mengenai pengesahan bahagian tepi objek dan ketika objek sasaran bergerak. Oleh itu, projek ini akan memperkenalkan sebuah teknik untuk robot humanoid mengenal dan belajar mengenai sifat sesuatu objek itu di dalam situasi yang terkawal tetapi pada masa yang sama mengesahkan corak anomali yang mungkin berlaku apabila terdapat senario di mana suatu objek terletak pada kedudukan yang terkeluar daripada tepi bingkai tersebut dan juga had saiz objek dari yang terkecil sehingga yang mampu menutupi seluruh bingkai. Ini menggunakan aplikasi sistem penglihatan untuk memeriksa ciri-ciri seperti bentuk, warna, dan nilai piksel sebelum mengesahkan lokasi dan corak anomali dengan tepat. Senario yang berlainan akan digunakan dalam eksperimen apabila dua lagi tambahan bingkai akan diletakkan bersebelahan bingkai yang sedia ada dan juga kedudukan serta saiz objek yang berlainan pada setip bingkai. Secara ringkas, semua pemboleh ubah dan prestasi bagi setiap eksperimen akan dijadualkan. Projek ini juga akan disimulasi menggunakan perisian platform robotik untuk menguji prestasi keadaan normal dan anomali di dalam situasi yang berlainan. Dengan 4 eksperimen yang berlainan, keadaan anomali dan juga keadaan normal dapat dibuktikan dan dibezakan. Menggunakan formula matematik, lokasi sebenar keadaan anomali di dalam satu bingkai juga dapat dicari. Apabila saiz objek dimanipulasi, nilai purata bagi keadaan anomali berbeza sebanyak 50% daripada keadaan normal dan nilai majoriti bagi sisihan piawai adalah dua kali ganda daripada nilai normal. Had untuk saiz objek ialah dari 0.4x0.4 cm sehingga 50x50 cm. Manakala, kesan daripada perbezaan kedudukan objek, perbezaan nilai purata sebanyak 0.01-0.04 dari situasi normal dan sisihan piawai adalah berubah-ubah. Nilai sisihan apabila objek diletakkan diantara dua bingkai adalah paling rendah berbanding apabila keseluruhan objek berada di dalam bingkai.

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Dist (Ci)	–	intra-class distance
$f\left(e_j^{C_i}\right)$,	–	Cluster member
$f(C_i)$	–	Cluster center
PPV	–	Positive Predictive Value
μ	–	Mean
σ^2	–	Variance
σ	–	Standard Deviation
$d(e_x, C_x)$	–	Smallest distance between $f(e_x)$ and $f(C_x)$
c	–	Hyphotenus from Pythagoras Theorem, c =$\sqrt{b^2 + a^2}$
b	–	Distance between robot and wall frame
a	–	Horizontal length of wall
X	–	Location of cuboid (in degree, ˚)

CHAPTER 1

INTRODUCTION

1.1. Project Background

Passing the decades, application and understanding of machine vision and robotics study are very worthy and advantageous especially for human being. One of the research that caught the attention of peoples are detection of objects or humans by using various methods of image segmentation in different type of surrounding or position. It is also known as anomaly or autonomous detection. Anomaly is defined as having low like hood or probability of occurrence in an environment. In simple way, the state of the object are deviating from normal or usual order.

Thanks to the technological modernity, anomaly detection is applicable in variety of domains. As an example, wilderness search and rescue (WiSAR), invasion detection, video surveillance security, fraud, error detection, system health monitoring, event detection in sensor networks, and detecting eco-system disturbances. Thus, it is very beneficial and useful to community. In general, there are several anomaly detection techniques that used knowledges of Machine Vision study and also study in Artificial Intelligence that involved fuzzy logic based outlier detection and neural networks. Anomalous behavior detection has applied advanced mathematical algorithms to find out the difference between abnormal and normal behavior, locate the point of anomalities and send alarm to highlights threats to the monitor or main controller.

Anomaly detection could be use in mobile robots or Unmanned Aerial Vehicle (UAV). By using these kind of robots, they can sense the anomaly behavior or abnormal scene in different areas of surrounding. In this millennium, there are many types of mobile robot such as KUKA Omnirob, Pioneer PD3X and humanoid robot.

While, humanoid robots that have been commercialized are iCub, Nao, Darwin - OP, ASIMO and HOBO. All these kind of humanoid robots have an active vision system, looks alike a human, very interactive and biologically inspired. Even so, as long as the main thing (sensor and camera) on the robot is existed and worked, they able to 'see' and scan the surrounding of a scene.

Briefly, the project are using V-Rep and Python software to show the process and simulation on how the work is operating. A Humanoid Robot is being used as the method to detect the anomaly behavior of the objects by implementing the image segmentation and image processing technique to get the output pixel value. This project also locate the static objects in different frames by using a single camera that on humanoid robot. Going through the report, it contains the problem statement, objectives and scope in Chapter 1 followed by literature study and background in Chapter 2. Next, explanation of proposed methodology, early result, conclusion and future work will be discuss in Chapter 3, 4 and 5 respectively. Besides that, necessary tables, charts and graphs also have been added in this report for describing or explaining some works process or a structure.

1.2. Motivation

Grounded from the hypothesis that anomaly behaviors should be different from the origin profile or has very low frequency, it generates the anomaly detection knowledge [17,18] that are being implemented mostly in vision application on many researches and work that needs observation mechanism. With respect to the original profile, we can learn and compare the subject's behavior either it is rare or never been seen before and has significant deviancy from the normal one.

Refer to [18,19,20] has proved that a reliable and automatic detection algorithm could impressively help operators from doing the monitoring in a long hours and makes the work more competent to follow up as an unfavorable event happens will be alarmed thus detected automatically. In recent period, to discover rare events in videos or pictures are the main concern in modern surveillance system for public security purpose, road accidents and product/item monitoring besides fraud detection.

This kind of detection technologies has employed the study of machine learning and statistical detection methods as the earlier behaviour or pattern of subject needs to be introduced through learning and cognition [14,16]. As for know, anomaly detection are one of the potential and exciting area of study to know. It also can be practically used in to improve country safety and military purpose as Malaysia placed number 12^{th} for world crime index 68.55% and safety index 31.45% in 2016.

1.3. Problem Statement

In this contemporary era, most of the researchers has been facing with the issues for vision study. One of the issues are about anomaly detection whereby the problem are about the features and illumination circumstances of objects [25], dense 3D shape models, images resolution, objects in different frames and others [21-24]. Although some of the proposed techniques and methods are working well under certain conditions, there are still significant degrades in terms of accuracy for detection of anomaly behavior. There are also percentage of error happened in some of the experiment cases. For instance, if high or low values for any variable is different from the by rights value, it will cause large error or variance, σ trade off. It also known as anomaly. By taking the example where the difference mean value from image pixels in first test and normal condition is very small. As an example the value is 0.02. There will be low variance error as it passed the range of normal variance. However, anomaly will be labelled when there is obvious difference in variance value between the normal and one condition.

So, the issue about objects in different frames which is one of the problem stated above will be tackled in this project. Additionally, this problem occur when there are confusion to detect an anomaly when there are different frames exist and the size of object are changeable. On top of that, the problem also rises when there is an object situated at the edge of the frame and when the object located in different position of the frame. This is because the current frame may not seem similar as the previous frame. It goes same as the pixel value in each image. Different image gives different mean and deviation of pixels value.

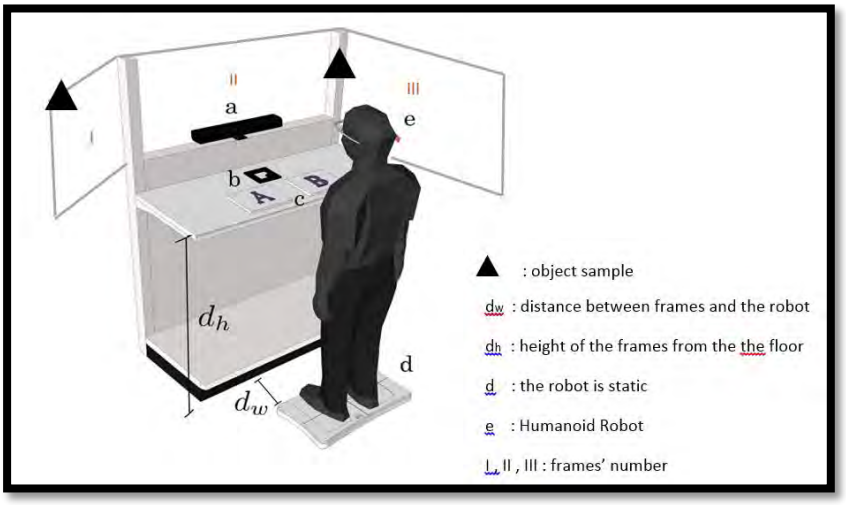

Figure 1.1 : General sketch for experiment setup with the objects at the edge and between 2 frames.

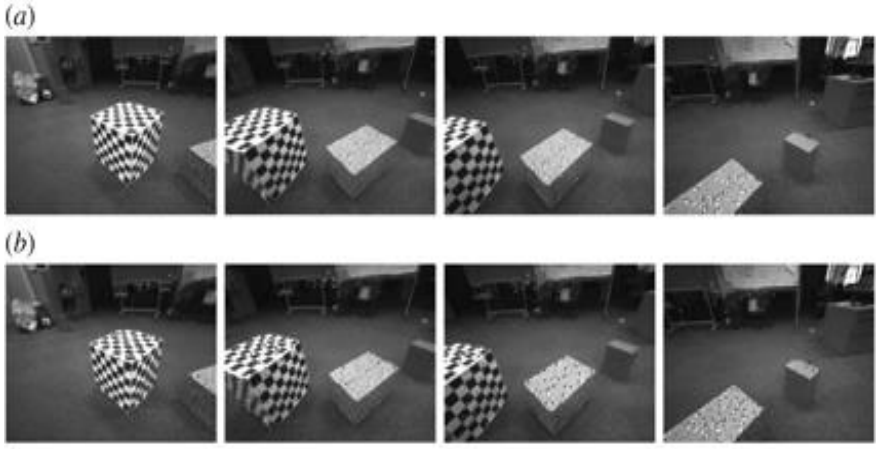

Figure 1.2 : Example of object models at the the edge of different frames [26].

Because of that, this project will compute the pixel image of the object, colour, position and size cues to combine them in chance for detect and recognize the anomalities and its limitations.

1.4. Objectives

This project embarks on the following objectives:

1. To detect anomaly behaviour of static objects by using a humanoid robot.
2. To tread anomaly behaviour of static objects in different frames by using a single camera in humanoid robot system.

1.5. Scope

The scope of this FYP project are the application of robotics and application of image recognition, synthesis and segmentation in machine vision. One of the categorized mobile robot which is humanoid robot is chosen as the method to conducting the anomalous detection in control surrounding and position. An important knowledge in robotics which is cognition ability are the main scope in this project as the robot must be capable to do identifying, memorizing and judging sets of subject in different frames. Thus, the robot is stationary but only the robot's head will be turning. Secondly, the type of sensor and camera is not being specify as the main goal of this project is to pinpoint the anomalous item and sense the subject in different frames. Ambient changes such as weather and lighting intensity also is being fixed during the working scene. The experiment platform will be simulating and operating only through V-Rep and Python (x,y) software.

1.6. Project Significant

This project have a purpose to do detection of anomaly object in different frames by using humanoid robot as platform for an active vision system. It is also tread the anomaly behavior whenever the object is located at the edge of frames or inside the frames with different object size and its position. Usually, researches about anomaly detection are tackled about the object in motion, ambient changes and human interactive robot experiment but detection of a fix object in one frame is not much popular. Significantly, this project can be implemented especially on monitoring based system which is video security or product inspection in manufacturing as it can comparing between the presence and absence of the object in a frame or when the object is located at the center or at the edge of a frame.

CHAPTER 2

LITERATURE REVIEW

2.1. Theoretical Background

In this chapter, introduction are about the basic knowledge on vision system followed by briefly discussion on robotic technologies that consists of three important knowledges in humanoid study which are locomotion, artificial intelligence and cognition. Machine vision reviewed about the development of the vision study and the concept throughout the years together with its application in numerous field. While, reviewed about robotics are the past history and development of humanoid robot together the concept applied in that three main knowledges.

2.1.1. Machine Vision

In this modern era, one of a typical and highly important task for an intelligent robotics is about visual exploration of unfamiliar environments. The concept of robots able to search for recognizable objects in an unknown environment is one of the conclusive goals for machine vision applications although there are some robots with visual capabilities. This is because, apparently the vision ability in robots seems improbable to be competed with human ability especially in brains and eyesight in a current time [1]. Despite that, it still can be studied and developed from day to day. This kind of technology needs two area of expertise which are vision and robotics as there are many concepts and theory needs to be concerned. Generally, Machine Vision (MV) is a 'simple' processing system which receives and combines signals from cameras by manipulating images at the pixel level.

This is for extract the information that can be used in a decision making activity to produce the output required. Butler stated in [1] that Machine Vision has several advantages over systems utility using conventional technologies.

On top of that, research and development into machine vision can be traced back for more than 30 years. As known, computer-based vision and automation tools are used in a wide variety of industrial and scientific applications, including electronics, automotive, semiconductor, pharmaceutical, and research applications. These systems perform process monitoring, information gathering, and “on-the-fly” feedback/control to correct manufacturing problems.

As time passed, machine vision study is increasing in the number of application due to the increase in computing power, new and better image processing algorithms, better quality in acquisition of images (hardware) and reliability of Artificial Intelligent (AI) tools [1].The significant of this studies have provided unnecessary time to developing the routine algorithms for image processing. Algorithms such as threshold, image manipulation, spatial filtering, Binary Large Object (BLOB) analyzing, edge detection, etc. are ready available.

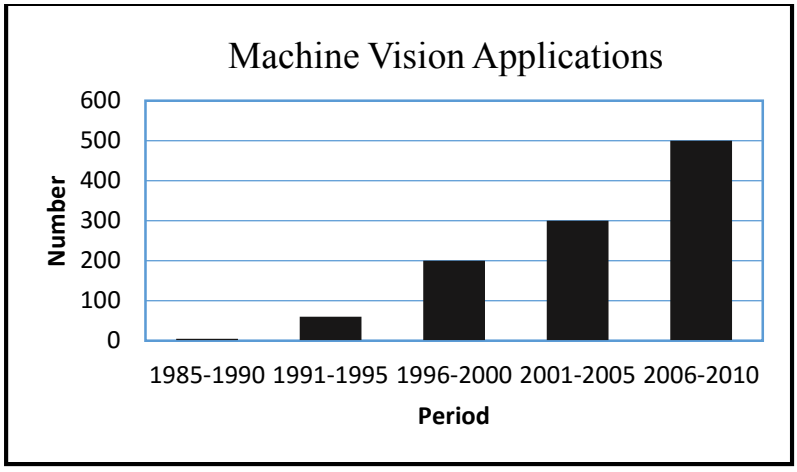

Figure 2.1 : Machine vision application during period of 25 years [1].

Based on the Figure 2.1, the application of machine vision in machines or robots has been ascending evenly in 5 years respectively, thus proved that the developments and technologies of this study has become more widen and vast.

Table 2.1 : Research statistics of machine vision applications on period 1980-2010 [1].

Field	MV Applications	%
General (theoretical) algorithms or technologies	158	15.16%
Industry related applications	259	24.85%
Control, Instrumentation	124	11.90%
Optics, Robotics, Computer Science	159	15.26%
Microorganisms,Living Cells, Variable Shape Objects	54	5.18%
Agriculture,Food Industry	135	12.96%
Flight Control, Car Control, Automatic Tracking, Traffic Safety	87	8.35%
Textile, Leather, Jewellery	66	6.33%

Based on the Table 2.1, it shows that almost ¼ of the fractions for machine vision applications is being applied in industry related applications followed by optics, robotics and computer science and next is general (theoretical) algorithms or technologies. In the field of microorganisms, living cells and variable shape objects, it can be shown that the number of applications is the least being used. The research represents a total of only 5.18% of the total machine vision applications. The main reason for this low number of applications is the fact that the living cells are has variant of size and shape. Furthermore, the application of machine vision to detect many type of object in different field represents the problems associated with the physical variance of objects and requires the development of specialized algorithms (large number of factors have to be taken into consideration) [2].

Vision plays a fundamental role for living beings by allowing them to interact with the environment in an effective and efficient way. As consequences, this is also the main reason why powerful Vision Software development platforms such as HALCON from MVTec Software, IMAQ from National Instruments, Visilog from Norpix and PatMAX from Cognex Corporation appeared on the market. It gave benefit to the people as they no longer necessary to spend long time developing routine algorithms for image processing.

The movement of computer vision from the "experimental technology" category into industry-strength mainstream applications have contributed many benefit. One of them is the amount of research undertaken in the development of more powerful equipment for image acquisition is increasing. Morover, colour cameras with mega-pixel resolutions has being widely available and used by many people in these present days. Methods for image fusion also has been widely investigated and applied successfully in various works depending on the data and desired results [30]. The lighting system for machine vision is continuously evolving, different solutions being growing up with respect to the application demand as pointed by Braggins [1].

For both image analysis and processing, emphasis on the errors usually can be occurred during the image formation and acquisition. The errors are more difficult and impossible to be eliminated, whether using image post processing algorithms. There are some limitations due to the accuracy of the object representation by an acquired image. Both, optics which forms the object image on the sensor and the digitization process can produce some errors. There are also several phenomena which directly influence the acquired image. Therefore, awareness during the working is very necessary stated by Ellenberger & Young in [1].

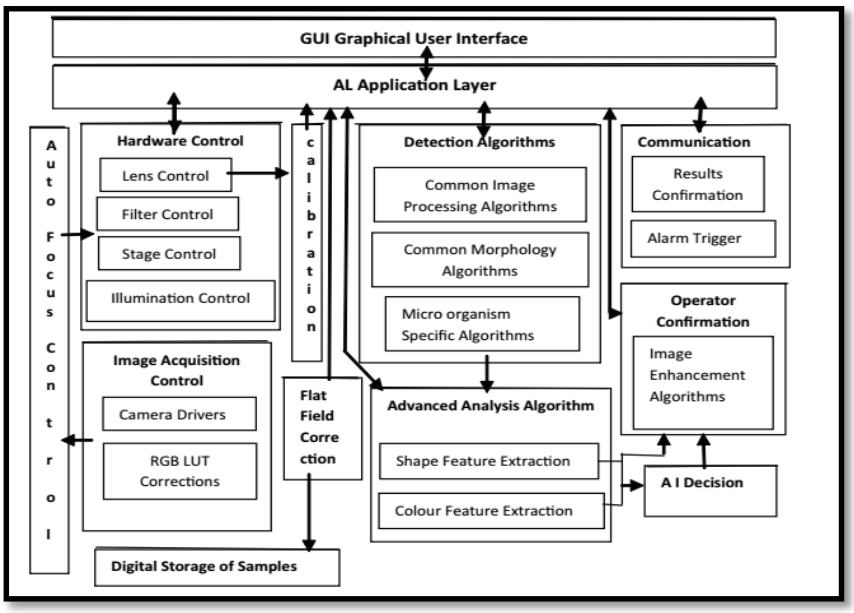

Figure 2.2 : Machine vision software architecture [30].

An eye for a human are very important for recognize and detection of an object even in a room that full of darkness. Without eyes, incidents may be happened due bumped to the obstacles, mishap or be at the unfamiliar environment. Edelman in [1] pointed out that there are some theories from researchers and scientist that explaining the human perception of objects. One of it is promote the importance of multiple model views while the others postulate viewpoint invariants in the form of shape primitives (geons) as stated by Tarr et al. and Biederman in [1]. However, from all the theories, the practical conclusion is that vision systems detecting objects in a human-like manner should use locally-perceived features fundamental tool for matching the scene content to the models of known objects. In a nutshell, this study can help or apply to a humanoid robot to have an ability to recognize an object and its position thus detect any anomalities in front of it.

2.1.2. Robotics

Following the trends in decade, robots becoming more capable because they able to do more tasks that might be dangerous or impossible for human workers to perform. As the complexity of tasks has increased, flexibility has been demanded. Every year, since the last two decades, people have been forecasting breakthroughs of services robots on the service robot market (Siegwart and Haegle) in [31].

In robotics, humanoid robots are one of the several types of robots. Humanoid robots are developed to use the infrastructures designed for humans. Not just that, they ease the interactions with humans, and to help the integrations into human societies. It can achieve to high speed of response to environmental changes. A humanoid robot is the embodiment of manipulative, locomotive, perceptive, communicative and cognitive abilities in an artificial body, similar to a human. They can be advantageously deployed as workers to perform tasks in different environment [3]. Cognition and perception of the robot forms a central basis for human intelligent behaviour. It allows us to detect and localize objects. Based on that, it perform tasks or to localize people and find the person on that time. The developments of humanoid robots evolve from building individual robots to establishing societies of robots working alongside with humans.

Therefore, there are 3 important knowledge in humanoid robotics study which are locomotion, cognition and Artificial Intelligence (AI).

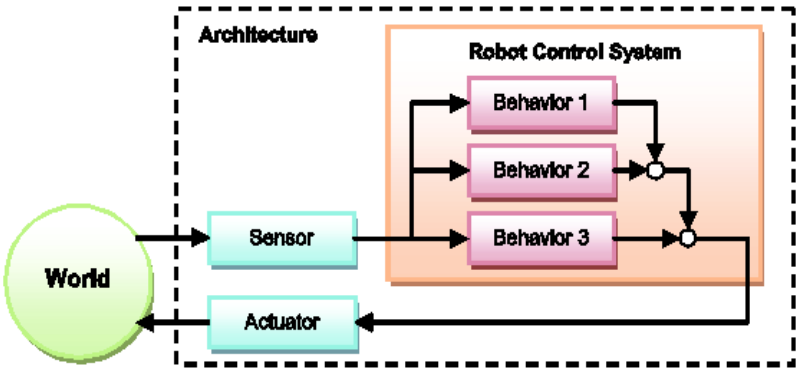

Figure 2.3 : Functional diagram of behavioral architecture of robot operate [32].

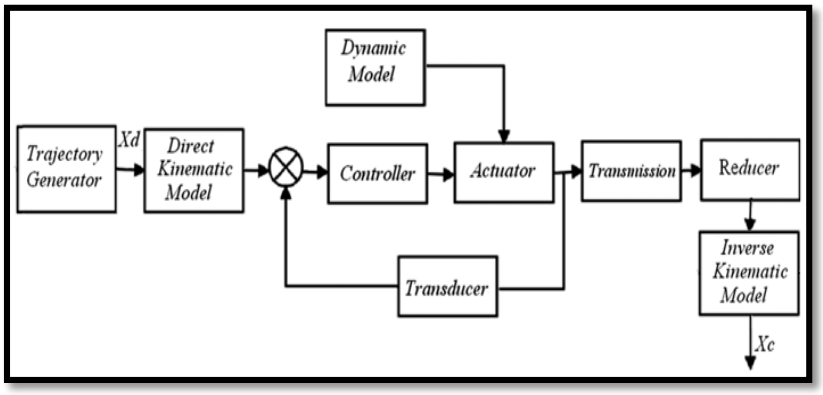

Figure 2.4 : Control structure of robot joint [32].

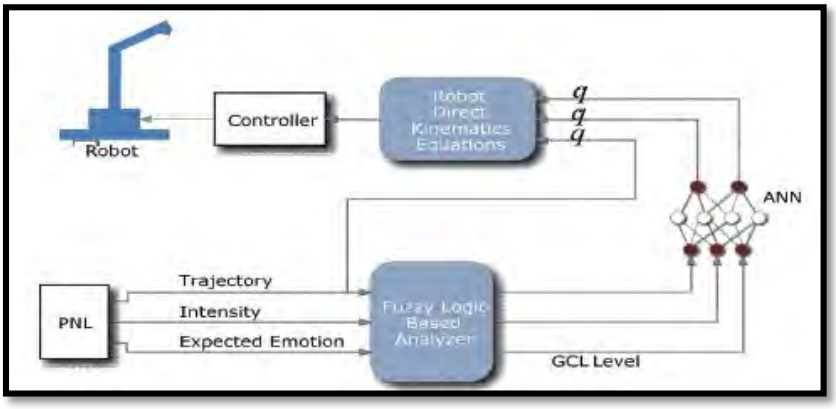

Figure 2.5 : The overall structure of intelligent robot motion system [4].