SUPERVISOR ENDORSEMENT

I hereby declare that I have read through this report entitle "Automated Waste Separated Machine" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechatronics Engineering.

Signature : .....

Supervisor's Name : .....

Date : .....

AUTOMATED WASTE SEPARATED MACHINE

LOW XIAN MIN

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

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

DECLARATION

I declare that this report entitled "Automated Waste Separated Machine" 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 mother and father

ACKNOWLEDGEMENT

First of all, I am grateful to Guatama Buddha for giving me the strength and health all the time, especially during the process of doing my Final Year Project in my final semester.

The way to do this report, I was in contact with many seniors from UTeM, researchers, academicians and practitioners. They had contributed towards my understanding and thought. I would like to take this chance to express my sincere appreciation to my main project supervisor, Pn. Nursabillilah Binti Mohd Ali, for encouragement, guidance critics and friendship. Without her continued support and interest, this project would not have been same as presented here.

I would also like to thank my girl-friend and housemates and others who have helped at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. Last but not lease, I am grateful to all my family members who trust and support me all the time.

Last but not least, I would like to thank my family members, Low Chee Beng (Father), Wong Choi Chun (Mother), Low Pei Pei and Low Pei Yee (Sisters) for supporting me 24 years in mentality or physically. Without them, I cannot perform so well to reach this stage. They always trust me and give me the strength to move forward without any fear.

ABSTRACT

Beverage container waste has been brought serious impacts to our environmental. For example, energy consumption of manufacturing drinking containers equivalences to 30 to 50 million barrels of crude oil each year. Besides that, process of making these containers generate large amount of greenhouse gas that causes global warming. Moreover, toxic is emitted to the air and water from the process of turn bauxite into alumina. Undeniable, demand of using drinking container is keep on rising, which cannot be eliminated. Hence, recycle is a method to be used to lower these impacts to the environment by controlling the quantity of drinking container available in our surrounding. Common way to perform recycle activity is using manually picking and sorting drinking bottle into categories but it is hard to solve the problem in long term due to high rate of beverage production and high cost to manage waste generated every day. Thus, machine vision is proposed to solve the problem.

Machine vision is one of the popular technique for object detection. The extent of this project is using machine vision to recognise type of waste (Note: Usual shape of drinking bottle) by extracting the colour of waste. Colour value (RGB) is transformed into HSV (Hue, Saturation and Value). Histograms are created for comparison between detected object and saved object in database. Then, sort them into different place by using machine learning. OpenCV library play a crucial role in this project, which is included in Microsoft Visual Studio 2012 with C++ language to write the coding for waste recognition.

As a summary, the machine vision colour detection is used to build Automated Waste Separated Machine and able to achieve 80% rate of success of waste detection.

ABSTRAK

Sisa bekas minuman telah membawa kesan yang serius kepada alam sekitar. Sebagai contoh, penggunaan tenaga bekas minum pembuatan persamaan yang 30 hingga 50 juta tong minyak mentah setiap tahun. Selain itu, proses membuat bekas ini menjana jumlah besar gas rumah hijau yang menyebabkan pemanasan global. Terlebih dahulu, toksik dipancarkan ke udara dan air daripada proses seterusnya bauksit menjadi alumina. Tidak dapat dinafikan, permintaan menggunakan bekas minum adalah terus meningkat, yang tidak boleh dihapuskan. Oleh itu, kitar semula adalah satu kaedah yang akan digunakan untuk mengurangkan kesan ini kepada alam sekitar dengan mengawal kuantiti bekas minuman terdapat di sekeliling kita. cara yang sama untuk melakukan aktiviti kitar semula menggunakan secara manual memilih dan menyusun botol minuman ke dalam kategori tetapi ia adalah sukar untuk menyelesaikan masalah dalam jangka panjang kerana kadar yang tinggi pengeluaran minuman dan kos yang tinggi untuk menguruskan sisa yang dihasilkan setiap hari. Oleh itu, penglihatan mesin dicadangkan untuk menyelesaikan masalah tersebut.

Penglihatan mesin adalah salah satu teknik yang popular bagi pengesanan objek. Sejauh mana projek ini menggunakan penglihatan mesin untuk mengenali jenis bahan buangan (Nota: bentuk Usual botol minum) dengan mengeluarkan warna sisa. nilai warna (RGB) berubah menjadi HSV (Hue, Saturation dan Undian). Histogram yang dicipta untuk perbandingan antara objek yang dikesan, dan objek yang disimpan dalam pangkalan data. Kemudian, menyusun mereka ke dalam tempat yang berbeza dengan menggunakan pembelajaran mesin. perpustakaan OpenCV memainkan peranan penting dalam projek ini, yang termasuk dalam Microsoft Visual Studio 2012 dengan C ++ bahasa untuk menulis kod untuk pengiktirafan sisa.

Sebagai ringkasan, pengesanan warna penglihatan mesin digunakan untuk membina Automated Waste Dipisahkan Mesin dan mampu mencapai kadar 80% kejayaan pengesanan sisa.

TABLE OF CONTENTS

CHAPTER	TITLE			PAGE
	SUPERVISOR ENDORSEMENT			**i**
	DECLARATION			**iii**
	DEDICATION			**iv**
	ACKNOWLEDGEMENT			**v**
	ABSTRACT			**vi**
	ABSTRAK			**vii**
	TABLE OF CONTENTS			**viii**
	LIST OF TABLES			**xi**
	LIST OF FIGURES			**xii**
1	**INTRODUCTION**			**1**
	1.1	Motivation		1
	1.2	Problem Statement		2
	1.3	Objective		3
	1.4	Scope		3
2	**LITERATURE REVIEW**			**4**
	2.1	Introduction		4
	2.2	Mechanical technique of waste sorting		7
		2.2.1	Manually recycle technique	7
		2.2.2	Infrared camera technique	8
		2.2.3	Near infrared and charged couple device camera technique	9
		2.2.4	Inductive Sensor Array and Colour Vision	10
		2.2.5	Pick and place technique	11

2.3	Image processing technique		14
	2.3.1	Introduction	14
	2.3.2	Histogram in image processing	15
	2.3.3	Logic Operation and Morphological in image processing	19
	2.3.4	Segmentation in image processing	21
	2.3.5	Colour in image processing	23
	2.3.6	Decision Based on Neighbourhood White Strip	27
	2.3.7	Object Shape Recognition	29
2.4	Summary of chapter		32
3	**METHODOLOGY**		**33**
3.1	Determine possible shape, perimeter and colour of bottles.		33
3.2	Hardware development		34
3.3	Software Overview and Selection		35
	3.3.1	VXL	35
	3.3.2	LTI	35
	3.3.3	OpenCV	36
3.4	Write coding for comparison and actuation between capture image and database image		39
3.5	Proof of concept by using Visual Studio C++ and Arduino		39
3.6	Electric circuit development		40
3.7	Development of full structure of mechanism		40
3.8	Proof of the Machine Vision with full structure of actuator		41
3.9	Experiment		42

	3.1	Flow chart of Automated Waste Separated Machine	44
	3.11	Flow of activities	45
4	**RESULT AND DISCUSSION**		**46**
	4.1	Introduction of image processing result	46
		4.1.1 Result from glass bottle test	51
		4.1.2 Discussion from glass bottle test	56
		4.1.3 Result from plastic bottle test	58
		4.1.4 Discussion from plastic bottle test	63
		4.1.5 Result from aluminium can test	65
		4.1.6 Discussion from aluminium can test	70
		4.1.7 Result from overall accuracy testing	72
		4.1.8 Discussion from final test (mixed bottle)	76
5	**CONCLUSION AND RECOMMANDATION**		**77**
	5.1	Conclusion	77
	5.2	Recommendation	79
6	**REFERENCES**		**80**
7	**APPENDIX**		**83**

LIST OF TABLES

TABLE	TITLE	PAGE
2.1	Comparison between Traditional and Recycle Waste Treatment	5
2.2	Mechanical technique overview	13
2.3	Image processing technique overview	30
3.1	Comparison between different types of machine vision software	37
4.1	Glass test 1 of ten input	51
4.2	Glass test 2 of ten input	52
4.3	Glass test 3 of ten input	53
4.4	Plastic (DESA) test 1 of ten input	58
4.5	Plastic (100 PLUS) test 2 of ten input	59
4.6	Plastic (DESA & 100 PLUS) test 3 of ten input	60
4.7	Can (Pepsi) test 1 of ten input	65
4.8	Can (Milo) test 2 of ten input	66
4.9	Can (Milo & Pepsi) test 3 of ten input	67
4.10	Final (mixed bottles) test 1 of ten input	72
4.11	Final (mixed bottles) test 2 of ten input	73
4.12	Final (mixed bottles) test 3 of ten input	74

LIST OF FIGURES

TABLE	TITLE	PAGE
2.1	Labourers differentiate the waste manually [9]	7
2.2	Spectra for HDPE, PP, PET and PS by using NIR [11]	8
2.3	Colour feature extraction for a plastic bottle in upright position image by machine vision [13]	9
2.4	Two-dimensional classification [12]	10
2.5	Close loop system [14]	11
2.6	a) Pick and place robot, b) Gripper [13]	12
2.7	Nine key stages in digital image processing [15]	15
2.8	Image enhancement by using histogram equalisation [15]	16
2.9	All five segmented regions and generated ROIs [16]	17
2.10	Bounding box image [16]	18
2.11	Block diagram of plastic bottle classification [16]	18
2.12	Image enhancement using AND operator [17]	19
2.13	Image enhancement using OR operator [17]	19
2.14	Set A, Structuring Element B, A eroded by B and Boundary machines of boundary extraction [17]	20
2.15	Result of using boundary extraction algorithm from binary image [17]	20
2.16	3x3 mask [15]	21
2.17	Initial population of 50 lines [18]	22
2.18	Final population and the thick black line (best-fitting element) [18]	22
2.19	Hue and saturation in the HSI colour model [17]	24
2.20	Concept of colour classification by using fuzzy and genetic algorithm [19]	26
2.21	The chromaticity graph of different type of glass bottles [19]	26
2.22	Flow of plastic sorting [20]	27

2.23	(a) Input image, (b) Extracted foreground, (c) White strips, (d) Contour boxes [20]	28
2.24	8-connected box for each white strip [20]	28
2.25	Example of shape detection [21]	29
3.1	Side view	40
3.2	Top view	40
3.3	Front view	40
3.4	Functionality testing of mechanism with LED light up	41
3.5	Console showed value of comparison of aluminium can	42
3.6	System flow chart	44
4.1	Method to compare images from camera and databased	50
4.2	Histogram of glass test result of 30 input	54
4.3	Glass was ready to be transferred	55
4.4	Glass rotated clockwise 225 degree	55
4.5	Histogram of 30 input plastic test result	61
4.6	Plastic bottle was ready to be transferred	62
4.7	Plastic bottle rotated clockwise 135 degree	62
4.8	Histogram of 30 input can test result	68
4.9	Aluminium tin was ready to be transferred	69
4.10	Aluminium tin rotated clockwise 180 degree	69
4.11	Histogram of 30 input mixed bottles test result	75

CHAPTER 1

INTRODUCTION

1.1 Motivation

Half a million years ago, human created very less garbage, the main reason was that human wasted very little. They reused and repaired most of what they had rather than replaced. When came to the Revolution of Industrial, which began in early 1700s, large amount of waste was produced. Products were made by machine rather than hand make, which meant that more goods could be made in cheaper way and could be produced in large amount [1].

Nowadays, they are a lot of beverage available in market like Coca-Cola and Pepsi. The common types of container to store the drink are plastic bottles, aluminium cans and glass bottles. People tend to throw away these empty bottles or cans after use. Without a good management to recycle all these bottles and cans, number of waste will be increased significantly. One day, natural resources will run out soon. A good waste management is a key point to build a sustainable community. Pollution can be reduced and resource can be preserved by recycling some key resource such as metal, glass and plastic that have been thrown in landfill. Therefore, recycle plays an important role to conserve our natural resources.

In China, around 3818 tons of metal, 11820 tons of glass, and 110190 tons of plastic are thrown away in 2006, these 3 type all waste cover around 14% of overall waste [2]. Furthermore,

Singapore also generates a huge volume of waste every day, which can cover up to 1030 football fields with a normal people height in a year [3].

In Malaysia, government enforced the law to sort all the waste in category, but there are a lot of users fail to do that. In statistic from Malay Mail Online, there are around 3000tonnes of waste being throw away in every single day in Malaysia [4].

In state of Melaka, statement shows that each resident generates 250kg of waste per year. The population of this state is around 872,900, it means that 218225tons of waste are thrown in a year [5]. All the statement shows that an effective way to separate waste should be invented to solve waste problem for better future. It is a main factor to build a sustainable community.

1.2 **Problem Statement**

Nowadays, there are a lot of soft drink and mineral water are served with plastic bottle, aluminium can and glass to make sure these drink can transport and sell in everywhere. Besides that, using these containers to store drink can ensure quality of taste and prevent metamorphic problem. There are a lot of favour drink sell in Malaysia like Pepsi, Milo, 100plus, Desa mineral and etc. Some of these drink fill in aluminium can, some fill in glass bottle and plastic bottle. All of it are designed and manufactured with different colour. If 6 people out of 10 in Malaysia buy at least one soft drink for their own daily, a huge number of waste are created everyday if proper waste management is not applied.

Furthermore, unbent drinking container waste normally occupy a lot of space in public dustbin. This is one of the reason of making dustbin overflow and smudge our surrounding. Manually picking and sorting for bottle into categories is not sufficient to encounter the problem in long term due to high rate of beverage production and high cost to manage waste generated. There are also no sensors can detect the property of bottle.

By solving this matter, initiative has to be taken to minimise the impacts bring to life. Using machine vision to replace human eye to detect and using Arduino Uno pair with gripper to sort all these bottles is one of a solution to perform the heavy task daily. For instance, plastic bottle and cans have its own unique colour and reflectivity of light. By using object's colour and

reflectivity of light comparison algorithm, machine vision technique able to perform object identification just like human. Furthermore, proper lightning and suitable position of camera are the key factors for less noise detection.

1.3 Objective

The objective of the research included:

1. To recognise object based on machine vision colour detection.
2. To design a mechanism to separate unbend waste bottle.
3. To analysis system performance.

1.4 Scope

Based on the process of designation and the consideration of limited time, the scopes of this project are listed as:

1. Focus on unbend or partially bent waste drinking bottles.
2. Emphasize on separation between 500ml 100 plus and DESA plastic bottles, 325ml brown colour glass bottles and 325ml aluminium cans.
3. The developed algorithms are used for unbent or partially bent waste bottle or can detection only.
4. A non-moveable camera is attached in a partially cover black box for bottle and can detection.
5. Open loop pick and place gripper can only pick, release and rotate 135, 180 and 225 degrees.
6. Performance of actual test will be affected by light intensity and reflective of light.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In China, landfilling is a technique for municipal solid waste (MSW) management. There is roughly 80~90 percent of the waste produced are disposed by this method. Based on their performed literature survey and analysis on this title, they come out the conclusion of the best way is to control the pollution source and cut off the pollution pathway [6]. This method of sorting does not consider the category of waste. Waste is simply thrown away after use and place in a place called landfill, which is the simplest way to solve waste management problem, but bring out a massive problem to the environment. For example, if the landfill without any landfill cap, leachate production will be increased. Thus, methane CH_4 emission cannot be decreased.

In the past decade, some developing countries pushing the speed of economic is the priority and ignored environmental problem is impossible to avoid. Hence, the whole world today pays more attention on wastes recycling as there is huge amount of wastes being thrown away day by day that cause a lot of problems like health issue and greenhouse effect. Recycle is a process which can convert wastes into useable materials. One of the outcomes from investigation shown that current waste treatment is not enough to recycle waste generated every day by just using man power. The result illustrated the highest rate of factor choosing waste disposal way is based on convenient which was rated as 3.36 [7]. Table 2.1 (Comparison between Traditional and Recycle Waste Treatment) below illustrated the summary between traditional waste treatment and recycled waste treatment.

Table 2.1: Comparison between Traditional and Recycle Waste Treatment

NO	Waste Treatment / Criteria	Traditional Waste Treatment	Recycle Waste Treatment
1.	Way to throw waste	Mix all waste and simply throw in dustbin.	Separate waste in categories and throw in certain platform.
2.	Processing waste	1. Landfilling 2. Incineration	1. Reuse 2. Reprocess to make new item 3. As fertilizer 4. Incineration
3.	Waste category	No (All mixed)	1. Recyclable 2. Kitchen 3. Harmful 4. Other
4.	Advantages	1. Save cost in waste treatment. 2. Save man power to separate waste. 3. Less process for waste treatment. 4.	1. Save natural resources. 2. Decrease environment health issue. 3. Produce sustainable community.
5.	Disadvantages	1. A lot of natural sources are wasted after used.	1. More and complicated steps are taken for waste treatment. 2. Increase cost for waste treatment.

		2. Methane CH_4 emission occurred at landfilled. 3. Greenhouse effect occurred due to methane gas. 4. Endanger health of wildlife.	3. More labourers are employed to sort waste manually. 4. Risk the life of labourers in manually sorting process.

2.2 Mechanical technique of waste sorting

In the following sections, the reviews included different kind of mechanical technique of waste sorting. These sections of study may provide the general ideas for this Final Year Project (Automated Waste Separated Machine) moves smoothly.

2.2.1 Manually recycle technique

There are several sorting methods to extract plastic from waste. The most common method was employing labourers to differentiate the waste manually in order to get out plastic material as shown in Figure 2.1 below. This was an easy way to identify target material, but, it exposed labourers to hazardous Health Care Waste (HCW), which were potentially at risk of being infected and injured. According to World Health Organization, under section 1.2.1 Occupational and public health risks, title number 8, during handling of wastes, the medical and ancillary staff as well as the sanitary labourers could be injured if the waste had not been packed safely. For example, sharp components were considered as one of the most dangerous category of waste. Many injuries occur because syringe needles or other sharps had not been collected in safety boxes or because these had been overfilled. On dumpsites, scavengers during their recycling activities may also come in contact with infectious waste if it has not been properly treated or disposed [8].

Figure 2.1: Labourers differentiate the waste manually [9]

2.2.2 Infrared camera technique

Other than using manpower, one of the technique was using infrared camera [10]. The method to identify near infrared (NIR) spectra of plastic material was provided in Figure 2.2. From this spectrum, a coefficient set was obtained by using wavelet analysis. After that, coefficients were used to form a quaternion number. This number was going to be compared with standard value in order to determine the plastic material, which provide more detail about the plastic. The advantages of this technique included of robust and insensitivity to the noise of the signal. However, this method was less accurate due to it based on a simple Euclidean distance.

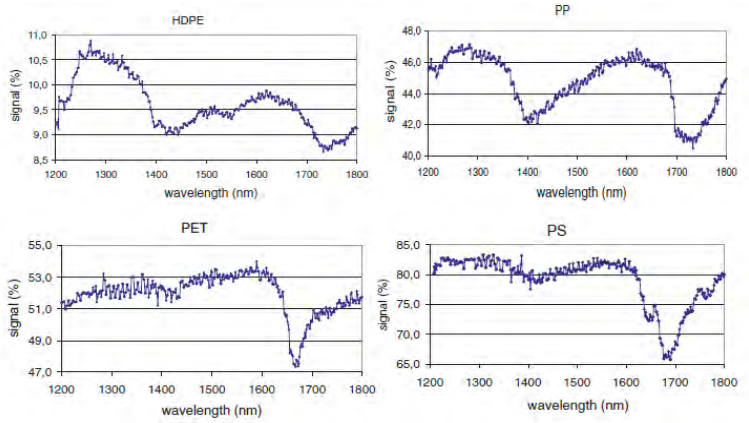

Figure 2.2: Spectra for HDPE, PP, PET and PS by using NIR [10]

2.2.3 Near infrared and charged couple device camera technique

Turning to the next point, a system that consisted two classification stages was developed [11]. The first stage is using Near Infrared (NIR) Spectroscopy to determine the type of plastic, which similar with the method of using infrared camera. The second stage was using machine vision based on a Charged Couple Device (CCD) camera. In addition, this method also integrated with quadratic discriminant function based classifier and decision tree classifier to increase overall colour classification accuracy as shown in Figure 2.3. This was probably due to it differed from one classifier to another for same colour. Unfortunately, this technique needed the bottle to be upright position, so that the sample could be scanned with minimal noise. Furthermore, this system become slower since the principle component analysis is added to do the adjustment.

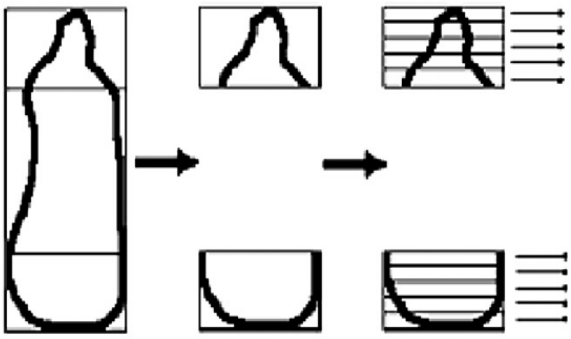

Figure 2.3: Colour feature extraction for a plastic bottle in upright position image by machine vision [11]

2.2.4 Inductive Sensor Array and Colour Vision

A sorting system for recycle metal scrap based on colour vison and inductive sensor was presented [12]. It combined two systems in a function to increase the ability of sensing different type of metal scraps. The colour detection was employing red channel as the common component which make comparison between green and blue value in order to find out the differences of colour as shown in Figure 2.4. Fluorescent bulb with high quality and efficiency was used to reduce the noise. Moreover, inductive system was used to measure the electrical properties of the metal for further confirmation of the metal properties. Hence, it abled to differentiate metals like steel, aluminium, copper and brass. However, the inductive system consisted of 52 sensors that performed the sensing function which not only increased the manufacturer cost but also raised the difficulty of machine learning. Sometimes, it was sufficient to use only machine vision to separate metals by just detect the colour them.

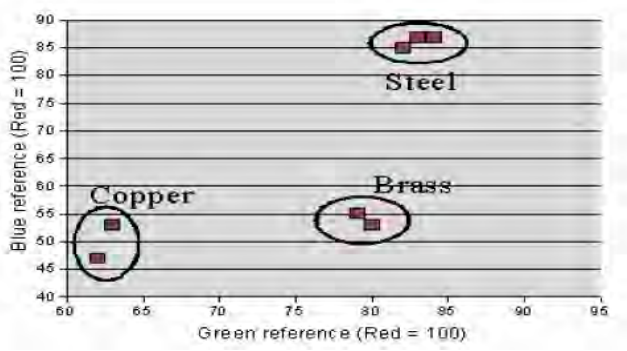

Figure 2.4: Two-dimensional classification [12]

2.2.5 Pick and place technique

Robot consisted three axes which let the robot to rotate in clockwise or counter clockwise, arm to move up or down and to extend and retract [13]. Some more, it consisted of gripper to that could open and close. The common actuators used was pneumatic cylinder that control by solenoid valve. Limit switch was included to trace the motion of cylinder. An example of operation shown the cylinder extended, its basement will rotate clockwise while retracted was another way around. The same cylinder not only could make rotational motion but also translational motion like arm extension. Easily speed control of the movement was one of the advantages of using pneumatic cylinder. An optional actuator included hydraulic cylinder. It used fluid compression instead of air compression. Comparison was made between pneumatic and hydraulic system. It illustrated that hydraulic system is more difficult to maintain due to its fluid leakage. Furthermore, it is more danger due to the leakage can easily cause fire [14].

Close-loop control was normally used in pick and place robot system. A feedback loop was included in the system to make adjustment of robot limb all the time. When there was difference between require position and limb position, the controller makes adjustment until the position of limb reaches to the desire positon. The closed-loop arrangement was shown in Figure 2.5 below.

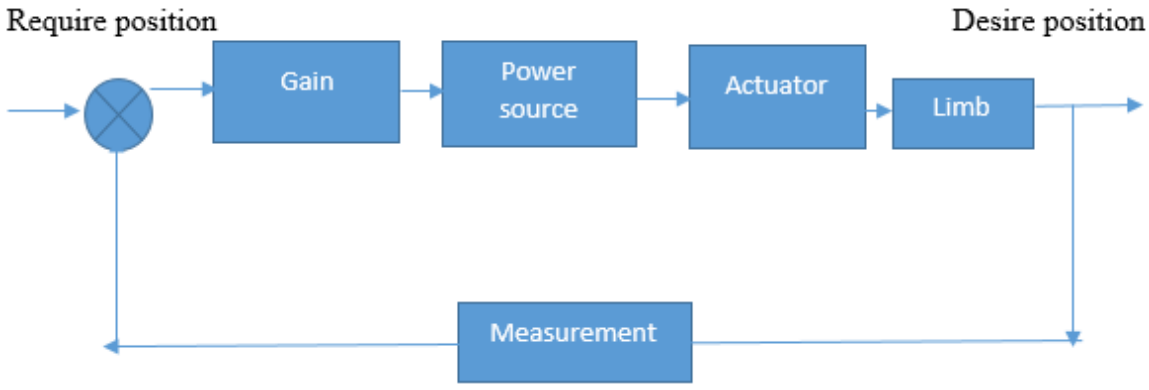

Figure 2.5: Close loop system [14]