TRACKING PLATFORM USING IMAGE PROCESSING

A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES
OF
NEAR EAST UNIVERSITY

By
Moustafa Slaimen

In Partial Fulfilment of the Requirements for the Degree of Master of Science in Mechatronic Engineering

NICOSIA, 2017

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MOUSTAFA SLAİMEN: TRACKING PLATFORM USING IMAGE PROCESSING

**Approval of Director of Graduate
School of Applied Sciences**

Prof. Dr. Nadire ÇAVUŞ

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

Object tracking is an important task within the field of computer vision. The efficiency of high-powered computers, the availability of high quality and inexpensive video cameras, and the increasing need for automated video analysis has generated a great deal of interest in object tracking algorithms. There are three key steps in video analysis: detection of interesting moving objects, tracking of such objects from frame to frame, and analysis of object tracks to recognize their behavior.

Image processing is a way to perform some techniques on an image, to get a segmented image or to output some useful information from it. It is a type of signal processing in which input is a picture and output may be picture or values associated with that image. The methodology of image processing in this thesis involves the application of color processing detection algorithm (CPDA). This thesis is a tracking platform using image processing and PID control system.

The aim of this project is creating fixed platform can track a moving target and aim a burning laser beam on it when it is captured. Platform's motors are controlled with the PID control and a camera placed on it that have algorithm can process an image to detect the target.

Keywords: Fixed platform; burning laser beam; degrees of freedom; PID control system; grayscale image

ÖZET

Nesne takibi, bilgisayarlı görü alanında önemli bir yere sahiptir. Güçlü bilgisayarların verimliliği, yüksek kaliteli ve pahalı olmayan kameraların varlığı ve otomasyonlu video analizine olan ihtiyaç, nesne takip algoritmalarına olan ihtiyacı da artırmaktadır. Video analizinde üç tane önemli adım bulunmaktadır: hareketli nesnelerin tespiti, bu nesnelerin kare kare takibi ve bu nesne takip analizi sonucunda nesnelerin davranışlarını tanımlamak.

Görüntü işleme, resimler üzerinde teknikler uygulayarak, bölütlenmiş resimler elde etmek veya bu resimlerden kullanışlı çıktılar elde etmek amacındadır. Görüntü işleme, girdisi ve çıktısı resim olan bir sinyal işleme alt dalıdır. Bu tezde, renk işleme tespit algoritması (CPDA) görüntü işleme tekniği olarak kullanılmıştır. Bu algoritma PID kontrol sistemi ile birleştirilerek izleme platformu oluşturmuştur.

Bu tezin amacı, görüntü işleme teknikleri ve PID control sistemi kullanılarak hareketli hedefleri takip edip yanıcı lazer başlığıyla bu hedeflerin yok edilmesini sağlayan sabit bir platformun oluşturulmasıdır.

Anahtar Kelimeler: Sabit platform; yanıcı lazer başlığı; bağımsız açılar; PID kontrol sistemleri; gri ölçekli resim

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Generally, the examination of moving objects, regardless of whether they are fire fronts, particles, beads, or liquid interfaces, was done physically, more often than not by measuring elements of a picture anticipated on a divider. This manual investigation was dreary and experienced numerous inadequacies, including poor precision and poor repeatability. The smoothness and impression of the divider or projection screen was an issue, similar to the strength of the projector and the poor lighting conditions. Since every one of the estimations were performed by hand and by eye, repeatability was dependably.

The moving objects following in video pictures has pulled in a lot of enthusiasm for PC vision. For protest acknowledgment, route frameworks and reconnaissance frameworks, question following is an irreplaceable initial step. Question following has centrality continuously condition since it empowers a few essential applications, for example, Security and observation to perceive individuals, to give better conviction that all is good utilizing visual data, In Restorative treatment to enhance the personal satisfaction for non-intrusive treatment patients and debilitated individuals, In Retail space instrumentation to break down shopping conduct of clients to upgrade building and condition outline, Video deliberation to acquire programmed explanation of recordings, to create protest based synopses, Activity administration to dissect stream, to distinguish mishaps, Video altering to dispense with awkward human administrator association, to plan advanced video impacts.

The Shading Picture Preparing and Protest Following Framework (Following Framework) was intended to beat these lacks. It was intended to be completely programmed, in this way expelling a portion of the mystery fi'om the investigation and also diminishing the repetitiveness of examining an extensive number of edges. Since the picture is changed over to computerized organize, it can be handled carefully, enhancing the picture and empowering less demanding discovery of edges. Now and again it might be ideal for the client to find the question physically

with a mouse as opposed to have the PC do it. The Following Framework permits this. The greater part of the picture handling that can be performed in the programmed following mode can in any case be performed in the manual mode, at the client's carefulness. A few following strategies (or modes) hatchet executed. A layout coordinating strategy can be utilized as a substitute to the robotized limit based technique. The layout coordinating strategies, including connection and a subtractive method, track picture highlights as opposed to edges. A locale parameters technique can track development of force based parameters, for example, power most extreme, least, and mean, in a chose stationary area. The last following strategy right now actualized is the territory estimation technique, which can be utilized measure scaled or nonsealed regions.

Question following in a mind boggling condition has for some time been an intriguing and testing issue (Yilmaz, 2006). In the remote detecting setting, it has frequently been connected to the utilization of aeronautical or satellite symbolism to track ground vehicle movement (Hinz, 2006). Calculations have been created to show vehicle following utilizing low-rate video or unmistakable symbolism groupings gathered by sensors on airplane (Szottka and M. Butenuth, 2011).

Airborne ghastly symbolism (Kerekes et al., 2006) and in addition phantom joined with polarimetric imaging (Presnar et al., 2010) have additionally been utilized to show the ability of remote detecting stages to track vehicles. In another application, satellite symbolism (Liu et al., 1997) alongside other information sources (Bruno et al., 2010) have been utilized to track sends in the sea. Moreover, manufactured gap radar airborne and satellite sensors have likewise been appeared to have surface question following capacities (Hinz et al., 2008).

CHAPTER 2
IMAGE PROCESSING

2.1 Introduction to Image Processing

The essential concept of image handling indicate to preparing of computerized image, became empty the clamor and with any classify of abnormalities sitting in a image use the advanced computer. The excitement or exceptionmustcreepin the imageeach center its adjustment or centermodificate and still on. For scientific examination, a image can bedescribe as a two-dimensional assimilationf(x,y) with x and y are locative (plane) facilitates, and the adequacy of at any match of capacity (x, y) is recognized as the power or deepscale of the picture by then. Whenever x, y, and its power assessment of f are all limited, separatedcontain, we call the image a computerized image. It is critical that an advanced image that is synthetic out of a limited number of strain, each of it has a particular area and esteem. These strain are called imagestrain, and pixels. Pixel is the extreme broadly utilized term to subserve the components of a computerized picture.

Various systems have been created in Picture Handling amid the final four to five contract. The greater part of the strategies are formed for upgrading pictures gotten from unamedprojectile, storage tests and military supervisionaviation. Picture Handling structure are obtained to be plainly prevalent n order to simplify theconductivity of dynamicwork forcing the PCs, comprehensivethe volumeof storetool, representation propagation and so forth.

Current computerized invention has creat it potential to lead multi-dimensional mark with frame that zone from basic advanced loop to harvesttheborder parallel of PCs. The goal of this observation can be separated in three classes: • Image Handling image in → picture out • Picture Examination image in → assessment out • Picture Understanding image in → annormal state depiction out it will crowd on the principal ideas of image preparing. area does not permit us to create more than a pair of early on comments about imageinspection. image understanding requires an approach that contrasts on a very basic level from the subject of this record. Promote, it will limit itselves to two–dimensional (2D) image preparing albeit the greater part of the

concept and procedures that are to be recorded can be prolonged out operative to at least three measurements.

 It is starting with certain primarysimplification. An imagedescribe in "this present reality" is concept to be a component of two actual factors, for model, a(x,y) plus the adequacy (e.g. splendor) of the picture at the true organize placement (x,y). A imageable to be reflected to include sub-pictures now and then suggested to as regions– of–interest, returns on initial capital investment, or onlyareas. This concept mirrors the road that images oftentimes implicatecollections of articles each one of it can be the cause for a space. In a reduplicateimage handling frame it should to be possible to stratifyspecificimage preparing process to chose part. Therefore one a agent in a image (area) able to be handled to smother movement inglorious while another pieceable to be prepared to promotetent version. The amplitudes of a given picture will quite often be either genuine numbers or whole number numbers. The last is generally a consequence of a quantization procedure that changes over a persistent territory (say, in the vicinity of 0 and 100%) to a discrete number of levels. In certain picture shaping procedures, notwithstanding, the flag may include photon numbering which infers that the abundancy would be characteristically quantized. In other picture shaping techniques, for example, attractive reverberation imaging, the direct physical estimation yields a mind boggling number as a genuine extent and a genuine stage. For the rest of this book we will consider amplitudes as reals or whole numbers unless generally demonstrated.

2.2 Digital Image Processing

Image processing is a mode used to promote frank images received from medical and military applications, satellites, and security cameras. The image is processed and analyzed using several techniques like image enhancement which include brightening, sharpening edge enhancement, etc. Majority of image processing techniques treating with two-dimensional images. Image processing is indicative processing where the input is a picture or video frames and the output is an picture or parameters related to it.

picture increase is the process of beneficent the type of digital images so that it can be interpreted by human or computers. Image enhancement include many algorithms such as filtering, extraction, correlation, and time compression. There are mainly two methods for image

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enhancement: first one deals with image in frequency domain and the other one deals with image in spatial domain. The frequency domain is based on Fourier series transformation and the other one is based on processing of individual pixels of the image.

In inferior inequality image, the relative characters combine pending binarization. It will use Power-Law Transformation to reduce the spread of characters before thresholding which raise the disparity of particle and support in preferable image segmentation. The Power-Law Transformation equation is given by $s = cr^\gamma$, which r and s are respectively the input and output density, c and γ are positive. The indicator in the power-law equation (γ) is indicate to as gamma correction.

The MATLAB park for Matrix Laboratory. It was written primarily to supply simple entrance to matrix software created and advanced by the LINPACK (linear system package) and with the EISPACK (Eigen system package) planner. The program has been commercially obtainable since 1984 and is now applied widely in most universities applications.

MATLAB is a high-execution and advanced parlance for solving artistic calculating issues. MATLAB has a progressing data structure, include built-in marking, simulation, and debugging stuffs which make him as an excellent programming software for teaching and research purposes.

Computerized picture preparing is the innovation of applying various PC calculations to handle advanced pictures. Results of this procedure can be either pictures or an arrangement of agent qualities or properties of the first pictures. Utilizations of advanced picture preparing have been ordinarily found in mechanical autonomy/astute frameworks, therapeutic imaging, remote detecting, photography and criminology (Zhou., 2010).

Flag handling is a teach in electrical designing and in science that arrangements with examination and preparing of simple and computerized signals, and manages putting away, separating, and different operations on signs. These signs incorporate transmission signals, sound or voice signals, picture signals, and different signs etc.

Out of every one of these signs, the field that arrangements with the kind of signs for which the information is a picture and the yield is additionally a picture is done in picture preparing. As it name proposes, it manages the handling on pictures.

It can be additionally isolated into simple picture handling and advanced picture preparing.

The expression digital image processing mostlyindicates to transformation of a couple-dimensional image by a digital PC. In a floppycondition, it suggests digital processing of any couple-dimensional data. A digital image is adisposition of true numbers demonstrated by a limited number of sting. The standardfeature of Digital Image Processing procedures is its variation, repeatability and the conservation of original data accuracy. The different Image Processing techniques are:

- Image segmentation
- Image preprocessing
- Image classification
- Image enhancement

2.2.1. Image segmentation

Division is one of the opener issues in picture handling. A well-known technique utilized for picture division is thresholding. After thresholding, a paired picture is shaped where all protest pixels had only one dim scale with all foundation pixels take added - by and large the question pixels are "dark" and the foundation is 'candid '. The preferable edge is the one that chooses all the protest pixels and charts them to 'dark'. Different methodologies for the programmed choice of the limit have been suggested. starting able to be characterized as charting of the dark scale in the double set {0, 1}:

$$S(x,y) = \begin{cases} 0 \ if \ g(x,y) < T(x,y) \\ 1 \ if \ g(x,y) \geq T(x,y) \end{cases} \tag{2.1}$$

which S(x, y) is the estimation of the portioned picture, g(x, y) is the dim scale of the pixel (x, y) and T(x, y) is the limit an incentive at the directions (x, y). In the least difficult state T (x, y) is facilitate free and a consistent for the entire picture. It can be chosen, for example, on the premise of the dim scale histogram. At the point when the histogram has a pair of articulated maxima, which contemplate dark scales of theme (s) and foundation, it is conceivable to choose a solitary limit for the whole picture.

A technique which depends on this thought and uses a relationship foundation to choose the best edge, is portrayed underneath. Occasionally dark level histograms have just a single greatest. This must be brought on, e.g., by inhomogeneous light of different areas of the picture. In this situation, it is difficult to choose a solitary verge esteem for the whole picture and a neighborhood binarization method (portrayed beneath) have be connected. universal strategies to take care of the issue of binarization of in homogeneously lit up pictures, be that as it may, are not accessible.

Division of pictures includes once in a while not just the segregation amongst items and the foundation, additionally partition between various districts.

The issues of picture division and gathering stay extraordinary difficulties for PC vision. Since the season of the Gestalt development in brain research (Wertheimer., 1938)], it has been realized that perceptual gathering assumes a capable part in human visual per-1 caption. An extensive variety of computational vision issues could on a basic level make great utilization of fragmented pictures, were such divisions dependably and effectively calculable. For example, middle level vision issues, for example, stereo and movement estimation require a fitting district of support for correspondence operations. Spatially non-uniform districts of support can be distinguished utilizing division procedures. More elevated amount issues, for example, acknowledgment and picture ordering can likewise make utilization of division brings about coordinating, to address issues, for example, figure-ground detachment and acknowledgment by parts.

While the previous couple of years have seen extensive improvement in eigenvector-based strategies for picture division (Weiss., 1999), these techniques are too ease back to be in any way functional for some applications. Interestingly, the strategy portrayed in this paper has been utilized as a part of extensive scale picture database applications as depicted in (Rattan et al., 1999). While there are different ways to deal with picture division that are very productive, these techniques by and large neglect to catch perceptually critical non-neighborhood properties of a picture as talked about beneath. The division method created here both catches certain perceptually essential non-neighborhood picture qualities and is computationally 2 effectives – running in O (n log n) time for n picture pixels and with low consistent variables, and can keep running practically speaking at video rates.

2.2.1.1 Global thresholding using a correlation criterion

regarding the verge trouble, lease g symbolizes the potential leaden amount in the main picture. Those amounts are described by the beneath- and above-verge instrumentation $\mu_0(T) \& \mu_1(T)$ of the main picture, presented with:

$$\mu_0(T) = \sum_{g=0}^{T} g p_g \left(\sum_{g=0}^{T} p_g\right)^{-1} \ and \ \mu_1(T) = \sum_{g=T+1}^{n} g p_g \left(\sum_{g=T+1}^{n} p_g\right)^{-1} \qquad (2.2)$$

Which g = 0, 1, ..., n all gray amounts with T ($0 < T < n$) is the verge scale. The eventuality compilation pg of gray amounts g is assumed by $p f N g g=$ wherever N is the full amount of pixels in the picture and $f g$ is the amount of pixels processing gray amount g.
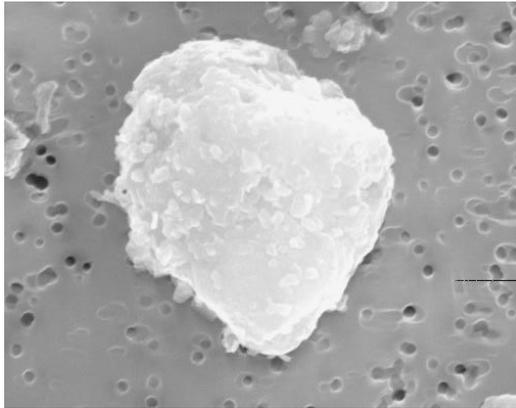
a) subordinate electron SEM picture of a municipal powder element
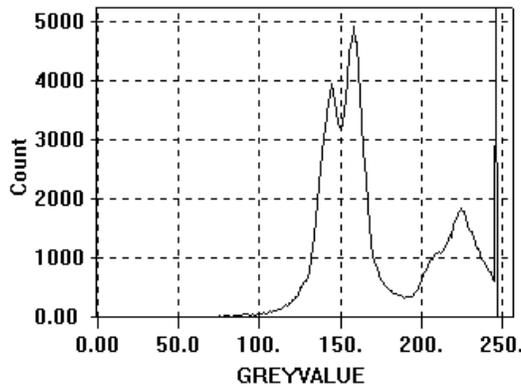
b) The gray scale histogram

Figure 2.1: The producer of stratify the connection standard setup

The difference represented by

$$V_x = E_{xx} - (E_x)^2, V_y(T) = E_{yy}(T) - \left(E_y(T)\right)^2 \qquad (2.3)$$

Actually, *Ex,Exx* & *Vx* are separated of the verge *T* that they are acquired from the main image. The connection degree given by

$$P_{xy}(T) = \frac{E_{xy}(T) - E_x E_y(T)}{\sqrt{V_x V_y(T)}} \qquad (2.4)$$

It is today a task from the verge scale. That optimum amount of *T* coincides to the amount that make the most of the connection through the true and the second amount pictures. This amount is set up by repetition. The effect of stratifying the mechanism to a subordinate electron SEM picture of a civilian powder character. As visible from the model, the connection procedure elected a significate verge.

2.2.1.2 Local binarization using discrete convolution
This mode of binarization is established on the implementation of the separated complication refinement mechanism that create a changed picture that is able to be simple threshold using 1 as the verge amount.
For resolution creating near a proper mathematical amount of stricture *p,* the grade of connection among the main and the involuted pictures is applied. It is elaborated as tracks:

$$r(p) = \frac{Cov(f, g(p))}{\sqrt{Var . Var(g(p))}} \qquad (2.5)$$

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Which f and $g(p)$ are the main gray scale image and the image involuted by means of amount for the limit, correspondingly.

| a) real picture | b) the gray level histogram |

| c) global thresholding | d) local thresholding |
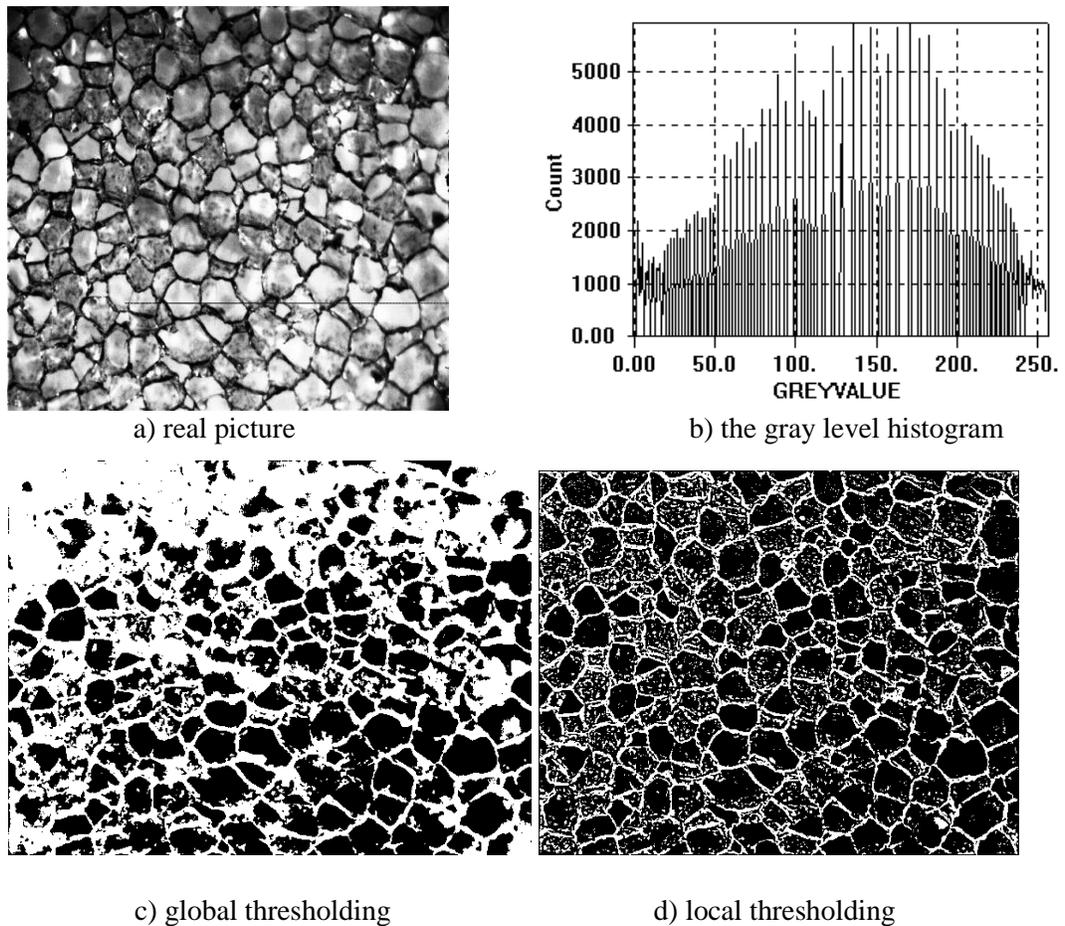
Figure 2.2: The 4 steps to the image binarization

2.2.1.3 Segmentation based on watershed transform

The technique for division in view of the utilization of borderer stripes was created in the system of scientific morphology. Look a picture f which is a topographic roof, characterize the catchment bowls and borderer crosses as far as a contracting procedure. Envision that every bore of the roof is punctured which have a surface is dove in a mere with a consistent straight speed. This water step inside that openings surges of the roof. The minute that the surges stuffing

two particular catchment bowls begin to combine, a barrage is raised with a specific end goal to forestall blending of the surges. The association of all barrages characterizes the watershed stripes of the picture f. There are distinctive PC executions of watershed calculations. Fundamentally, they are able to be partitioned in two gatherings: calculations, which reproduce the overwhelming procedure and strategies going for immediate location of the watershed focuses.

2.2.1.4 Edge Detection Operators

Roberts edge detection: according to (Roberts.,1965) The Roberts operator implement easy, fast to calculate, 2-D locative inclination calculation on an image. It thus important areas of a rising locative gradient which often coincide to borders.

In judgment, the technique includes of a couple of 2×2 gyration covers as shown in Figure First visor is easy the different alternate by 90°.

The value is presented:

$$|G| = \sqrt{Gx^2 + Gy^2} \tag{2.6}$$

though typically, convergent dimension is calculated using:

$$|G| = |Gx| + |Gy| \tag{2.7}$$

whose is the faster to enumerate.

The degree of direction of the border presenting elevation to the locative tendency (depend on the pixel of the grid orientation) is presented by:

$$\theta = arctan\left(\frac{Gy}{Gx}\right) - \left(\frac{3\pi}{4}\right) \tag{2.8}$$

Employing this visor, the convergent volume is presented by

$$|G| = |P_1 - P_4| + |P_2 - P_3| \qquad (2.9)$$

Prewitt edge detection: this edge detection was developed by Judith M. S. Prewitt. Appreciation to the volume of the border Prewitt is on the right direction. Likewise, extraordinary angle edge identification needs a completely time weariness computation to discover the heading from the qualities in the x and y-bearings, the range border admission discover the route particularly from the piece with the ultimate noteworthy answer.

Sobel edge detection: the Sobel system is utilized as a part of picture preparing, particularly inside edge identification program. It is a separated separation director, registering an estimate of the angle of the image values work. Thus, the ingredient of the inclination might be detect employing the attached parataxis:

$$\frac{\delta f(x,y)}{\delta x} = \Delta x = \frac{f(x+d_{x,y})-f(x,y)}{d_x} \qquad (2.10)$$

$$\frac{\partial f(x,y)}{\partial y} = \Delta x = \frac{f(x+dx,dy)-f(x,y)}{dy} \qquad (2.11)$$

which dx & dy figure range straight the x & y instructions correspondingly. In separated picture, only one can look at dx & dy is numbers of pixel through2 facts. dx = dy = 1 (pixel spacing) is that point at that pixel assortment are (i, j),

$$\Delta x = f(i+1,j) - f(i,j) \qquad (2.12)$$

$$\Delta y = f(i,j+1) - f(i,j) \qquad (2.13)$$

With a view to find the turnout of a propensity intermission, one could figure the variation in the slope at (i, j). This able to be completed by detecting the attached dimension:

$$M = \sqrt{(\Delta x)^2 + (\Delta y)^2} \qquad (2.14)$$

And the orientation θ is presented by

$$\theta = arctan\frac{\Delta y}{\Delta x} \tag{2.15}$$

Processing the pseudo-convolution factor as presented.

Using this mask, the convergent dimension is presented by

$$|G| = |P_1 - P_4| + |P_2 - P_3| \tag{2.16}$$

Canny edge detection: According to (Canny.,1986) The fundamental objective of this Edge detection are the followings:

1- Elevated level of detection: have a depressed endurance of unsuccessful to realize the true edge points, and have a depressed endurance of false doing thenon-edge points. Since jointly these endurances are lessening functions of the produce signal-to-noise rate, this standard coincides to maximizing signal-to-noise rate. So essentially, it hastes sign as numerous true border as potential.

2- Abnormal state of confinement - The call attention out as borders concentrates by the manager should to be adjacent conceivable to focal point of the genuine border.

3- Least reaction - the one reaction to outright edges. It is certainly caught the principal rule since from there are two reactions to a similar border, one of them have to be investigated not genuine.

2.2.2 Image preprocessing: in image preprocessing, image data registered by prospector on a disciple confines errors recognized with geometry and brilliance appreciations of the pixels. those mistakes are remedied employed proper scientific samples, whose are each clear or the volumes samples. Image improve is the adjustment of image in variable the pixel luminosity goodness to promote its visible impact. Image improve contains a collection of strategies that are applied to promote the visible occurrence of an image, or to modification through the image to a framework, which is more capable for epidermal or engine elucidation.

2.2.3 Image classification: the recreation comes about verified that the planned controlling achieves improved with the combined broadcast vivacity metric from the most extreme quantity of recoils metric. The projected intention springs vivacity productive mode to evidence broadcast and augments the generation of total organization. By way of the performance of the projected control is broke down among two capacities in upcoming through a rare adjustment in plan examinations the implementation of the projected intention can be compared and additional vivacity productive control. We take applied petite organization of 5 centers, as number of centers expands the intricacy will increase. We can build the number of centers and break down the implementation.

2.2.4 Image enhancement: one imperative subjects in picture preparing is picture improvement. Picture improvement includes a gathering of systems which are utilized to enhance the graphic entrance of a picture, or to change over the picture to a shape, that is more qualified for humanoid or engine elucidation. Isn't broad hypothesis of picture upgrade cause being broad standard for the nature of a picture. In this manner, diverse classes of strategies were created over the previous decades.

CHAPTER 3

HARDWARE PART

3.1 Arduino (UNO/atmel328)

Arduino Uno is an incredible decision for your first Arduino. It has 14 advanced data/yield pins (of which 6 can be utilized as PWM yields), 6 simple data sources, a USB jack, power input, a reset button and the sky is the limit from there. It contains everything expected to bolster the microcontroller; essentially associate it to a PC with a USB (Ladyada.,2014). Shown in Figure 3.1.
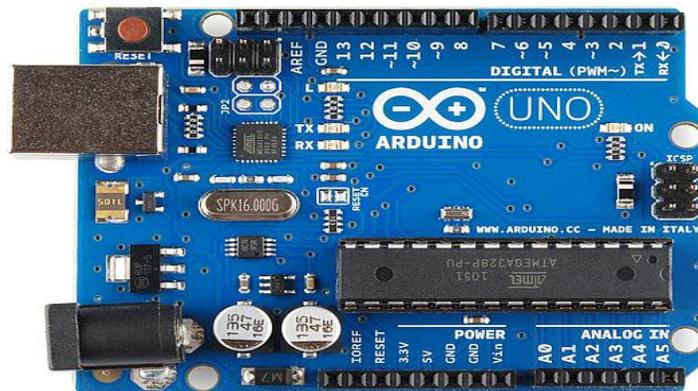
Figure 3.1: Arduino (UNO)

3.2 Burning laser

When the target is captured (appears at the middle of the screen) Arduino turns on the laser which is pointed at the target. Shown in figure 3.2

Specification:

Power: 5mw.

Wavelength: 532nm.

Figure 3.2: Burning Laser

3.3 Servo motor (SG90)

3.3.1 PWM:

Pulse width modulation (PWM) is a technique for twofold flags era, which has 2 flag periods (high and low). The width (W) of each heartbeat changes in the vicinity of 0 and the period (T). The fundamental rule is control of energy by shifting the obligation cycle.

The rotational speed of a DC motor is directly proportional to the average value of the supply voltage. The higher this value, the faster the motor will rotate. By varying the "Duty Ratio" (D), t ON/t OFF, the average value of the motor voltage and hence its rotational speed can be varied. Shown in figure 3.3
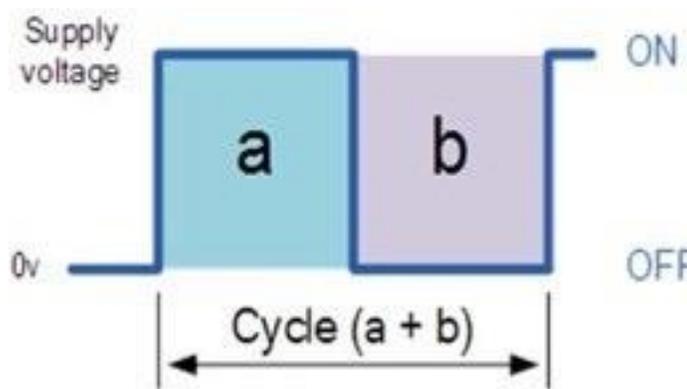

Figure 3.3: PWM (duty cycle)

For better comprehension of PWM these diagrammatic portrayals can be utilized. These figures speak to the waveforms gotten as yield at various voltage requirements.

Rapid Signal (90%): The green some portion of the signal is on time and the white some portion of the same signal shown to off time when it is not having any voltage. Shown in the figures below.
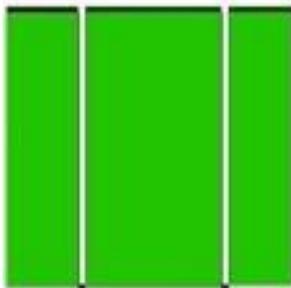

**Figure 3.4:** Signal with High voltage (90%)
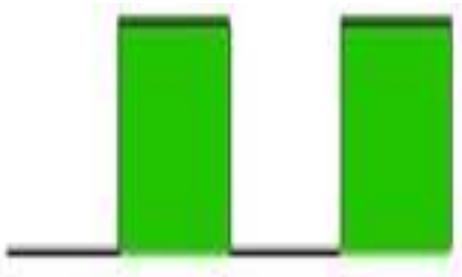
Figure 3.5: Signal with Half voltage (50%)
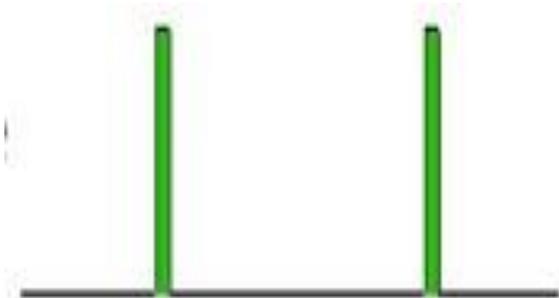
Figure 3.6: Signal with Low voltage (10%)

3.3.2 Servo motor:

Its position is defined by the width of duty cycle of the PWM pulses arriving from Arduino. Shown in Figure 3.7.

This will redirect the mechanical structure towards the target.
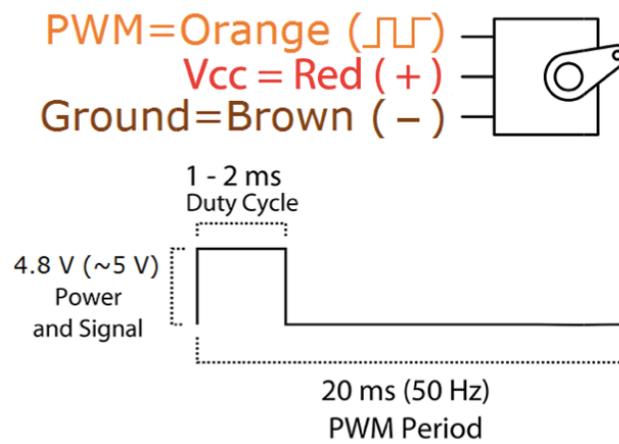
Figure 3.7: PWM Period in Servo Motor

Figure 3.8: Servo Motor (SG90)

Table 3.1: Specifications

Weight	9 g
Stall torque	1.8 kgf cm
Speed	60 degree/0.1s
Voltage	4.8 V (~5V)

CHAPTER 4
EXPERIMENTAL SETUP

4.1 Aim

A platform carrying a camera has two degrees of freedom (2 rotations: Azimuth, Elevation) and burning laser beam, the two degrees of freedom of the platform are to be controlled in order to keep a moving object (the target) at the same axis of laser beam and burn it.

Figure 4.1: Platform

4.2 System Overview

As shown in Figure 4.2, the PC gets images from the camera (cam), processes these images to get current position of the target and calculates the error values to be sent to servo motors via the Arduino.

Axis of laser beam is aligned with axis of the camera axis.
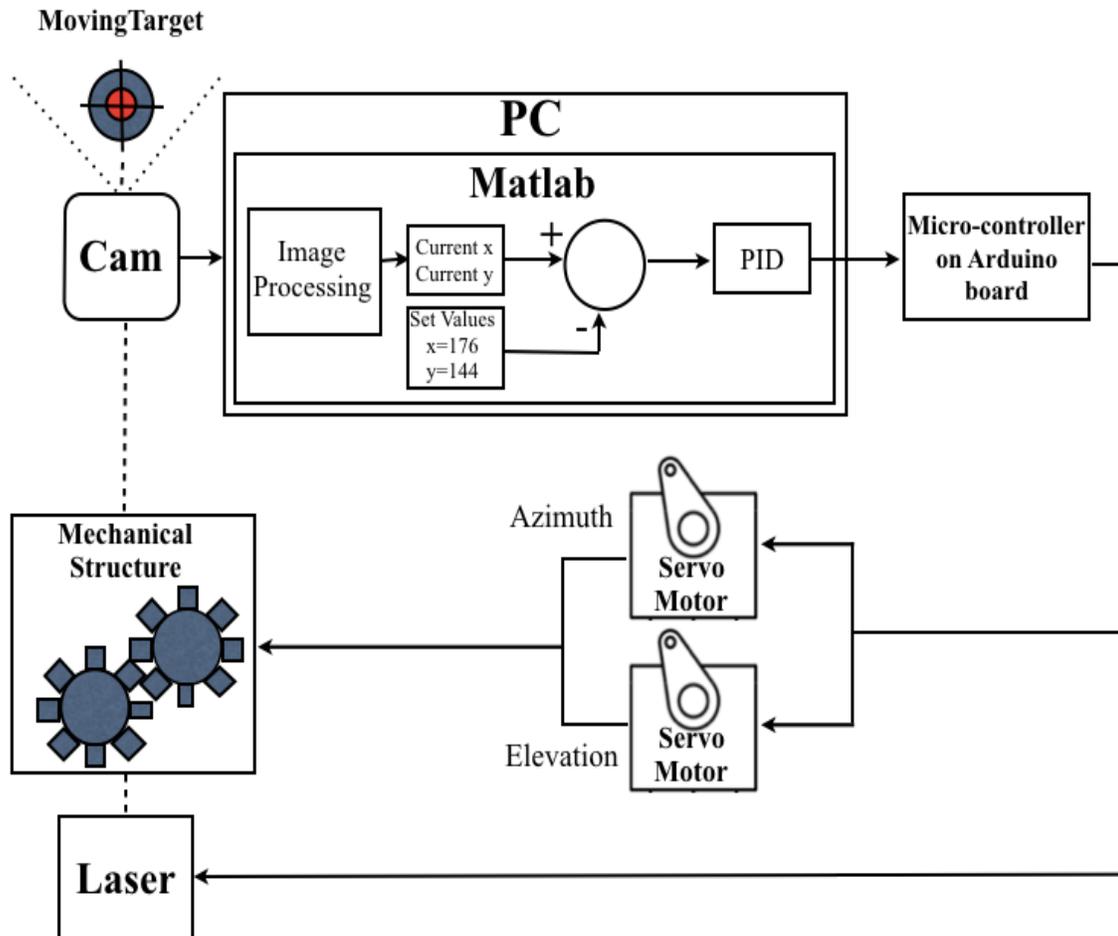
Figure 4.2: Block Diagram of tracking platform

4.3 System Components

4.3.1 Camera

A true HD-quality video camera capable of recording at frame rate up to (30 fps) is connected to pc via USB. Shown in figure 4.3

Figure 4.3: Camera brand (A4TECH)

This camera is chosen because it has ability to recording at 30 fps.

4.3.2 MATLAB (v.2013b) on the PC

4.3.2.1 *Image processing*

Get snapshots streamed from the camera, with 352*288 pixels and RGB color frames at (30 fps).

Image processing in the system need special environment not containing the color of the target.

For each snapshot do some tasks to get blue components: shown in figure 4.4
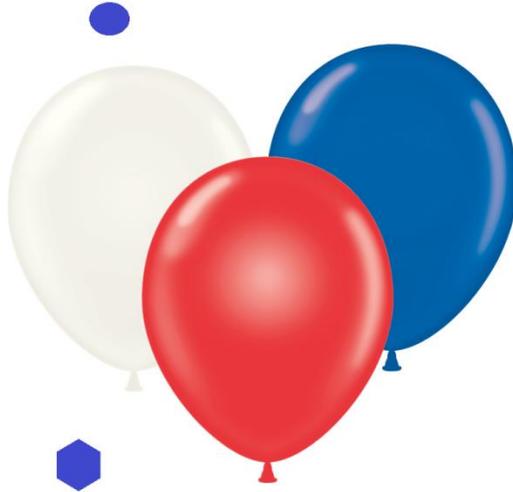
Figure 4.4: Snapshot

A- Create a grayscale image and blue component image from the original image (snapshot).

B- Subtract the grayscale image from blue component image as shown in Figure 4.5

Figure 4.5: Subtraction Result

C- Convert the result into a binary image, based on a threshold as shown in Figure 4.6
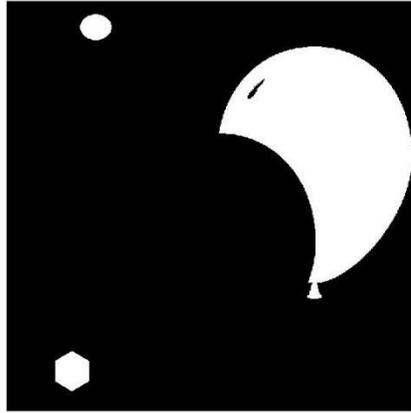
Figure 4.6: Convert to Binary Image

D- Remove small objects from binary image as shown in Figure 4.7
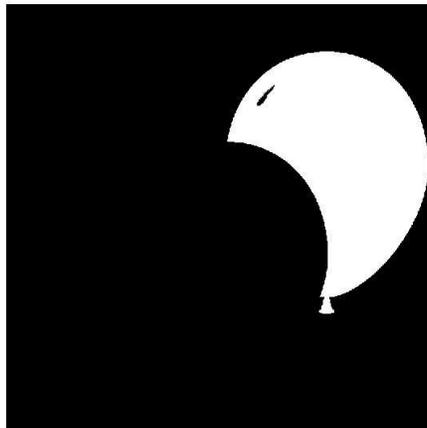
Figure 4.7: Remove objects those less than 400px

E- Label all the connected components in the image and set properties for each labeled region.

F- Display calculated properties on the original image: shown in Figure 4.8.
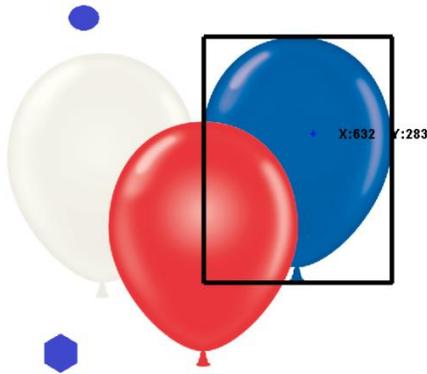
Figure 4.8: Label Connected Components in 2-D Binary Image
(At the end of image processing we get the centroid [X, Y] of the target).

4.3.2.2 *Controlling*

A- Compute the deviation of the centroid from the center of the image (Δx,Δy) and compute the driving parameters of the servo motors according to (Dorf., 2008) the PID formula.

$$U(t) = K_p \Delta(t) + K_i \int_0^t \Delta(t)\, dt + K_d \tag{4.1}$$

B- If the target is in the middle turn on the burning laser.

C- Send appropriate command to Arduino (serial communication via USB).
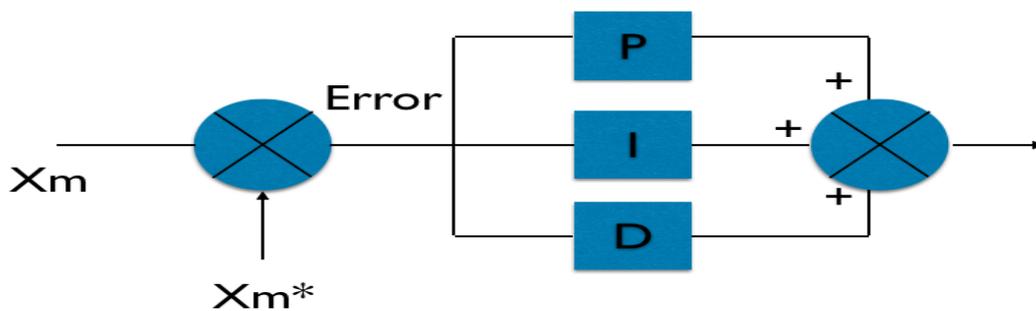
Figure 4.9: Block diagram of the PID system

Table 4.1: tuning of proportional and derivative in the PID system

K_p	K_d	Number of error
1	1	40%
5	1	35%
10	5	20%
15	5	13.5%
20	5	12.5%
20	10	8%
25	10	13%
25	15	21%

4.3.3 Mechanical structure

Constructed with plexiglass, fiber and iron.

A- Ensures as accurate movement as possible:

plexiglass damps vibration caused by the continuous and rapid movement.

B- Servo motor will move faster when the torque is reduced therefore we have to reduce the weight of platform as possible:

Fiber is Light and durable at the same time and our system need these characteristics.

Figure 4.10: Mechanical structure A

Figure 4.11: Mechanical structure B

4.4 Flowchart
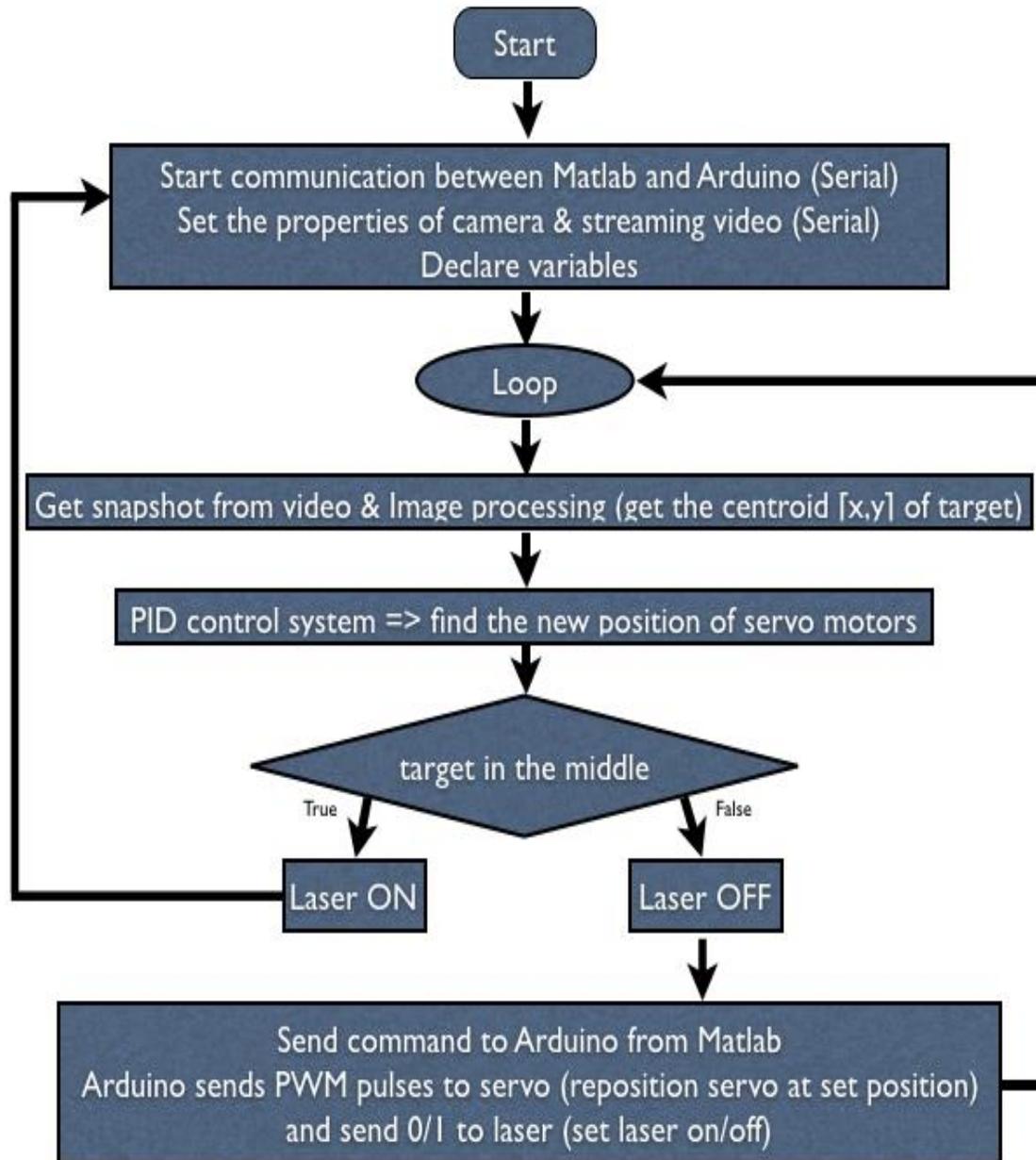
Figure 4.12: Flowchart of platform tracking

As shown in Figure 4.12 the communication starts between MATLAB and Arduino (serial), set properties of camera and streaming video (serial).

Start the loop and get snapshot from video then process the snapshot to get the center of target. Using PID control system to evaluate the error should be sent to Arduino that move servo motor to set position (track the target).

If the target at the axis of laser beam turn on the burning laser to burn the target.

CHAPTER 5
SYSTEM ANALYSIS

5.1 Error Evaluation Procedure and Calibration Factor

Calibration tests are organized such that the performance of the system with different configuration parameters can be compared to each other.

The calibration Test:

A- Using Lumion software a video is created in which a target is moved along a set trajectory with controlled speed. Shown in Figure 5.1

The platform is placed in front of the screen displaying this video. The system is required to continuously track the target as it moves. An error is considered when the centroid of the target [x or y] exceed a set threshold. The number of errors is summed over the duration of the test.
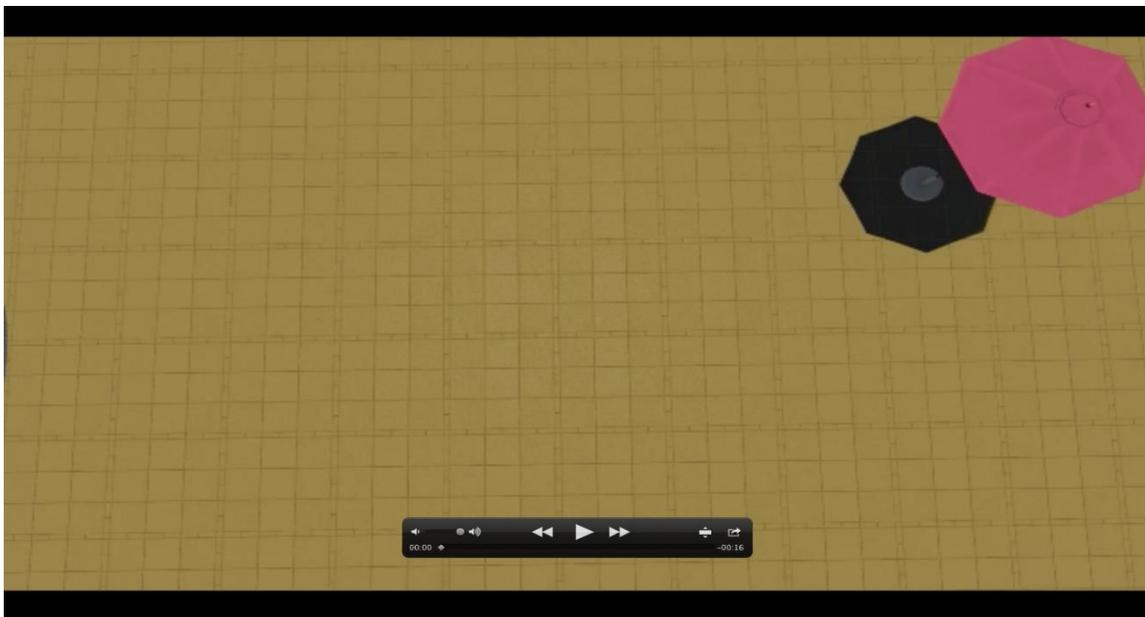
Figure 5.1: Calibration Test

B- Figure 5.2 shows how errors are detected during the test. Two errors are detected during the whole cycle consisting of four snapshots there for this test gets the total mark of 2/4 =50%. The aim of calibration test is to tune the system with the least possible number of errors (approximately 0%) at the high speed as possible.
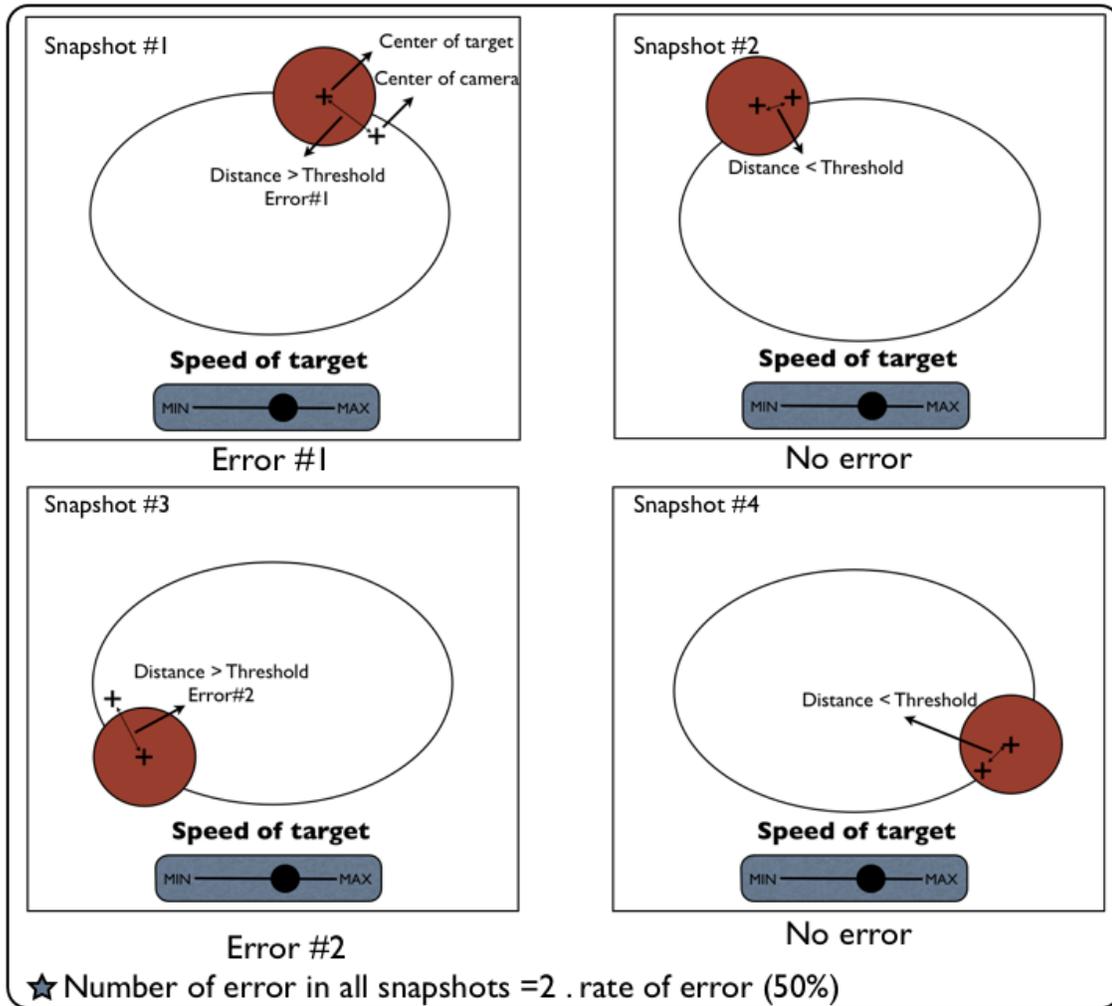
Figure 5.2: Detect errors

Calibration the factors:

I made a lot of tests to calibrate the two factors:

1- Proportional factors x, y.

2- derivative factor (prediction factor). Shown in Figure 5.3
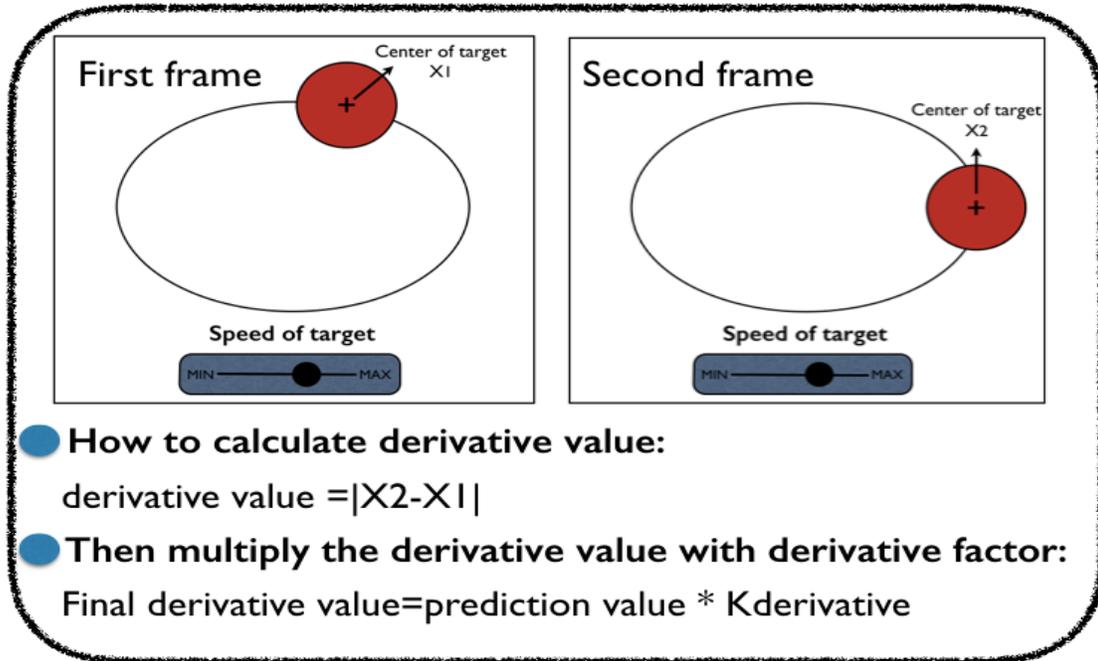
Figure 5.3: Explain derivative factor

The proportional factors are calibrated before then the prediction factor.

The choosing of factors depends on number of errors (minimum errors).

Speed of objects that tracked in video (Calibration test) =1.7m/s.

The distance between the platform and screen 2 meters or 3 meters.

Too many thresholds are used to calculate the error in our tests, threshold is the area of camera pixels, if the target out of this threshold the errors counter count the error else no error. In my test we calculate the errors in 1000 frames so the percentage of error depends of the number of frame example:

If the number of errors=150 =>the percentage of the error is 150/1000=15%.
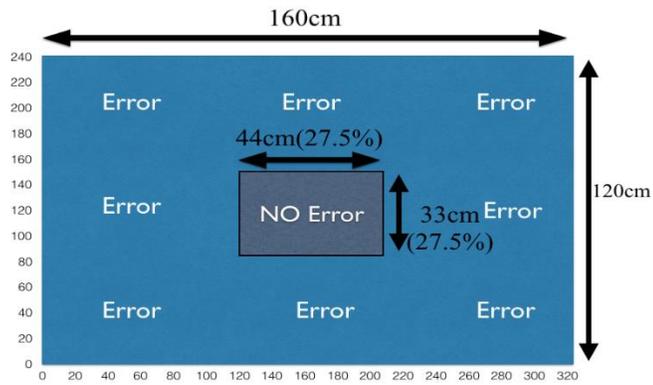
Figure 5.4: Distance 2 meter and threshold 27.5%

Table 5.1: Distance 2 meter and threshold 27.5%

Calibration proportional factor

proportional factor x	proportional factor y	number of error	prediction factor
1/13	1/15	over shot	0
1/14	1/16	over shot	0
1/15	1/17	17%	0
1/16	1/18	14.9%	0
1/17	1/19	13.4%	0
1/18	1/20	11%	0
1/19	1/21	14.8%	0
1/21	1/23	22.2%	0

Calibration proportional factor

proportional factor x	proportional factor y	number of error	prediction factor
1/18	1/20	8.8%	1
1/18	1/20	7%	1.5
1/18	1/20	9%	2
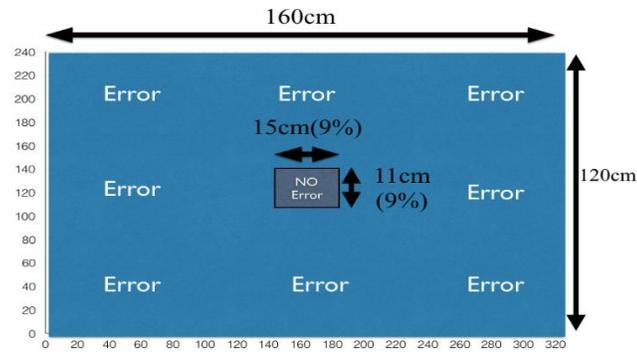
Figure 5.5: Distance 2 meter and threshold 9%

Table 5.2: Distance 2 meter and threshold 9%

Calibration proportional factor

proportional factor x	proportional factor y	Number of error	Prediction factor
1/13	1/15	over shot	0
1/14	1/16	over shot	0
1/15	1/17	21.6%	0
1/16	1/18	18%	0
1/17	1/19	16.7%	0
1/18	1/20	14.8%	0
1/19	1/21	18%	0
1/21	1/23	26.9%	0

Calibration proportional factor

| proportional factor x	proportional factor y	Number of error	Prediction factor
1/18	1/20	12%	1
1/18	1/20	10.2%	1.5
1/18	1/20	11.1%	2

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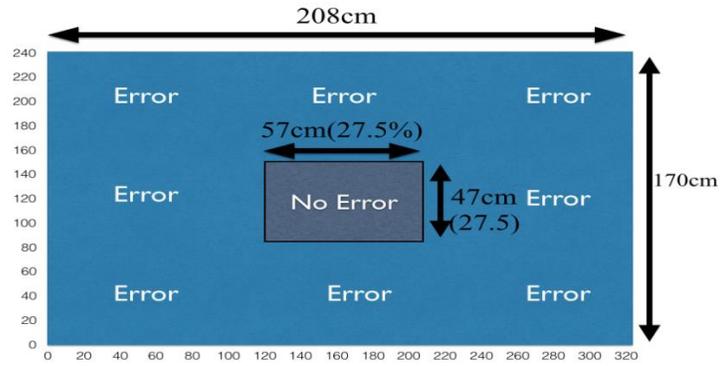
Figure 5.6: Distance 3 meter and threshold 27.5%
Table 5.3: Distance 3 meter and threshold 27.5%

Calibration proportional factor

proportional factor x	proportional factor y	Number of error	Prediction factor
1/13	1/15	over shot	0
1/14	1/16	over shot	0
1/15	1/17	15%	0
1/16	1/18	13.5%	0
1/17	1/19	12.5%	0
1/18	1/20	9.5%	0
1/19	1/21	13%	0
1/21	1/23	21%	0

Calibration Prediction factor

| proportional factor x	proportional factor y	Number of error	Prediction factor
1/18	1/20	7%	1
1/18	1/20	5.5%	1.5
1/18	1/20	6.4%	2

35
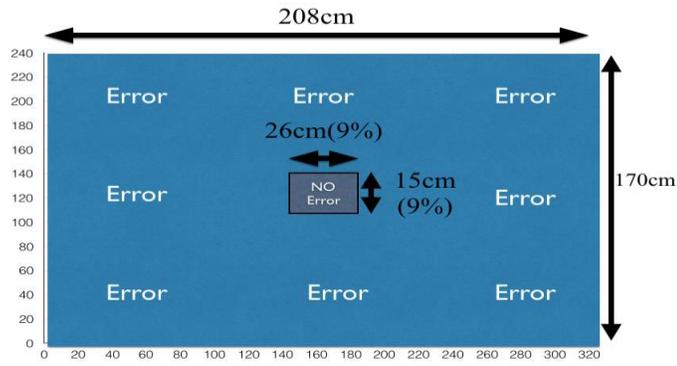
Figure 5.7: Distance 3 meter and threshold 9%
Table 5.4: Distance 3 meter and threshold 9%

Calibration proportional factor

proportional factor x	proportional factor y	Number of error	Prediction factor
1/13	1/15	over shot	0
1/14	1/16	over shot	0
1/15	1/17	18.2%	0
1/16	1/18	16.9%	0
1/17	1/19	16.1%	0
1/18	1/20	13.3%	0
1/19	1/21	13.5%	0
1/21	1/23	23%	0

Calibration Prediction factor

proportional factor x	proportional factor y	Number of error	Prediction factor
1/18	1/23	8.6%	1
1/18	1/20	8.9%	1.5
1/18	1/20	9.6%	2

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CHAPTER 6
CONCLUSION

6.1 Conclusion

After finding the method that can process an image and detect the target using color processing, then according to PID control system we write algorithm can track the target and keep it at axis of laser.

While we werre using the standard test, we found the suitable PID Proportional integral and derivative factors for good tracking, using the plexiglass and fiber that ensures as accurate movement as possible. Plexiglass damps vibration caused by the continuous and rapid movement of servo motor will move faster when the torque is reduced therefore we have to reduce the weight of platform as possible.

Fiber is Light and durable at the same time and the system need these characteristics. In this thesis, we mainly worked as system integrator. Our task was to choose the appropriate components and to combine them in order to achieve the required functions. This explains the variety of subsystems and their combinations in this project.

Final results of the work showed that, the developed platform can track moving objects that move with 1.7m/s and the PID factor equals:

The proportional factor in x axis =1/18.
The proportional factor in y axis =1/20.
The derivative factor in x axis and y axis = 1.5

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APPENDICES

APPENDIX 1

MATLAB CODE

```
a = imaqhwinfo;
b = arduino('COM14');
w b.servoAttach(10);
b.servoAttach(11);
b.pinMode(5,'Output');
b.pinMode(6,'Output');
v = videoinput('winvideo',2, 'YUY2_352x288' );
servo1=140;
servo2=80;
b.servoWrite(10,servo1);
b.servoWrite(11,servo2);
% Set the properties of the video
set(v, 'FramesPerTrigger', Inf);
set(v, 'ReturnedColorspace', 'rgb')
kp=19;
kp_y=23;
kd=1;
pred_x=0;
pred_y=0;
kpred=1.33;
flag1=0;
flag0=0;
%start the video
start(v)
while(1)
    tic
% Get the snapshot of the current frame
    c = getsnapshot(v);
```

```matlab
% Now to track red objects in real time
% we have to subtract the red component
    e = imsubtract(c(:,:,2), rgb2gray(c));
% Convert the resulting grayscale image into a binary image.
    e = im2bw(e,0.19);
% Remove all those pixels less than 250px
    e = bwareaopen(e,600);
% Label all the connected components in the image.
    cc = bwlabel(e, 8);
% We get a set of properties for each labeled region.
    stats = regionprops(cc, 'BoundingBox', 'Centroid');
% Display the image
flag0=0;
    figure(1);imshow(c)
hold on
for object = 1:length(stats)
    flag0=1;
    bb = stats(object).BoundingBox;
    bc = stats(object).Centroid;
    rectangle('Position',bb,'EdgeColor','r','LineWidth',5)
    plot(bc(1),bc(2), '*')
    x= num2str(round(bc(1)));
    y= num2str(round(bc(2)));
    m=text(bc(1)+50,bc(2), strcat('X: ', x, '    Y: ', y));
    set(m, 'FontName', 'Arial', 'FontWeight', 'bold', 'FontSize', 14, 'Color', 'yellow');
    x=str2num(x);
    y=str2num(y);
if(flag1==1)
    pred_x=x0-x;
    pred_x=pred_x*kpred;
    pred_y=y0-y;
```

```matlab
    pred_y=pred_y*kpred;
end
switch(x)
case num2cell(140:220)
switch (y)
case num2cell(80:160)
        b.digitalWrite(6,0)
        b.digitalWrite(5,1)
otherwise
        b.digitalWrite(5,0);
end
otherwise
     b.digitalWrite(5,0);
end
%%%%kd=time/0.035;
%%% left xxxxxxxxxxxxx
if(x<174)
switch(x)
case num2cell(0:50)
            servo_step_x=kp;
case num2cell(50:100)
            servo_step_x=kp+1;
case num2cell(100:174)
            servo_step_x=kp+2;
end
mx=176-x;
mx=mx+pred_x;
mx=mx*kd;
mx=mx/servo_step_x;
switch(mx)
case num2cell(0.2:0.5)
```

```matlab
    mx=1;
otherwise
mx=round(mx);
end
servo1=servo1+mx;
switch(servo1)
case num2cell(0:180)
b.servoWrite(10,servo1);
case num2cell(-1000:0)
    servo1=0;
case num2cell(180:10000)
    servo1=180;
end


%%%% right xxxxxxxxxxx

elseif(x>178)
switch(x)
case num2cell(178:242)
        servo_step_x=kp+2;
case num2cell(242:292)
        servo_step_x=kp+1;
case num2cell(292:352)
        servo_step_x=kp;
end

mx=176-x;
mx=mx+pred_x;
mx=mx*kd;
mx=mx/servo_step_x;
switch(mx)
```

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```matlab
case num2cell(-0.5:-0.2)
    mx=0;
otherwise
mx=round(mx);
end
servo1=servo1+mx;
switch(servo1)
case num2cell(0:180)
b.servoWrite(10,servo1);
case num2cell(-1000:0)
    servo1=0;
case num2cell(180:10000)
    servo1=180;
end
end
end

%%%% up yyyyyyyyyy

if(y<120)
switch(y)
case num2cell(0:50)
        servo_step_y=kp_y;
case num2cell (50:100)
        servo_step_y=kp_y+3;
case num2cell(100:120)
        servo_step_y=kp_y+4;
end
my=122-y;
my=my+pred_y;
my=my/servo_step_y;
```

```matlab
switch(my)
case num2cell(0.2:0.5)
     my=0;
otherwise
my=round(my);
end
servo2=servo2+my;
switch(servo2)
case num2cell(0:180)
b.servoWrite(11,servo2);
case num2cell(-1000:0)
     servo2=0;
case num2cell(180:10000)
     servo2=180;
end

%%%% down yyyyyyyyyy

elseif(y>124)
switch(y)
case num2cell(124:208)
        servo_step_y=kp_y+4;
case num2cell (208:258)
        servo_step_y=kp_y+3;
case num2cell(258:288)
        servo_step_y=kp_y;
end
my=122-y;
my=my+pred_y;
my=my/servo_step_y;
switch(my)
```

```matlab
case num2cell(-0.5:-0.2)
     my=0;
otherwise
my=round(my);
end
servo2=servo2+my;
switch(servo2)
case num2cell(0:180)
b.servoWrite(11,servo2);
case num2cell(-1000:0)
     servo2=0;
case num2cell(180:10000)
     servo2=180;
end
end
end
flag1=1;
x0=x;
y0=y;
end

    hold off
 time=toc
end


% Stop the video
stop(v);
```

Hint : Arduino code is from library to make stream between Matlab and Arduino (serial).

APPENDIX 2

ARDUINO

Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

- **5V.** This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

- **GND.** Ground pins.

- **IOREF.** This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

Memory

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM

Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USBto-TTL Serial chip.

- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.

- **PWM: 3, 5, 6, 9, 10, and 11.** Provide 8-bit PWM output with theanalogWrite() function.

- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication using the SPI library.

MISO (Master In Slave Out) - The Slave line for sending data to the master,

MOSI (Master Out Slave In) - The Master line for sending data to the peripherals,

SCK (Serial Clock) - The clock pulses which synchronize data transmission generated by the master

and one line specific for every device:

SS (Slave Select) - the pin on each device that the master can use to enable and disable specific devices.

- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().

- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

AREF:

This is the analog voltage reference. It can be used in stead of the standard 5V reference for the top end of the analog spectrum.

IOREF:

This is a voltage corresponding to the i/o of that board, for example an Uno would supply 5v to this pin, but a Due would supply 3.3v

Programming

The Syrduino Uno can be programmed with the Arduino software .

The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol .

USB Over current Protection

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

SYRDUINO One

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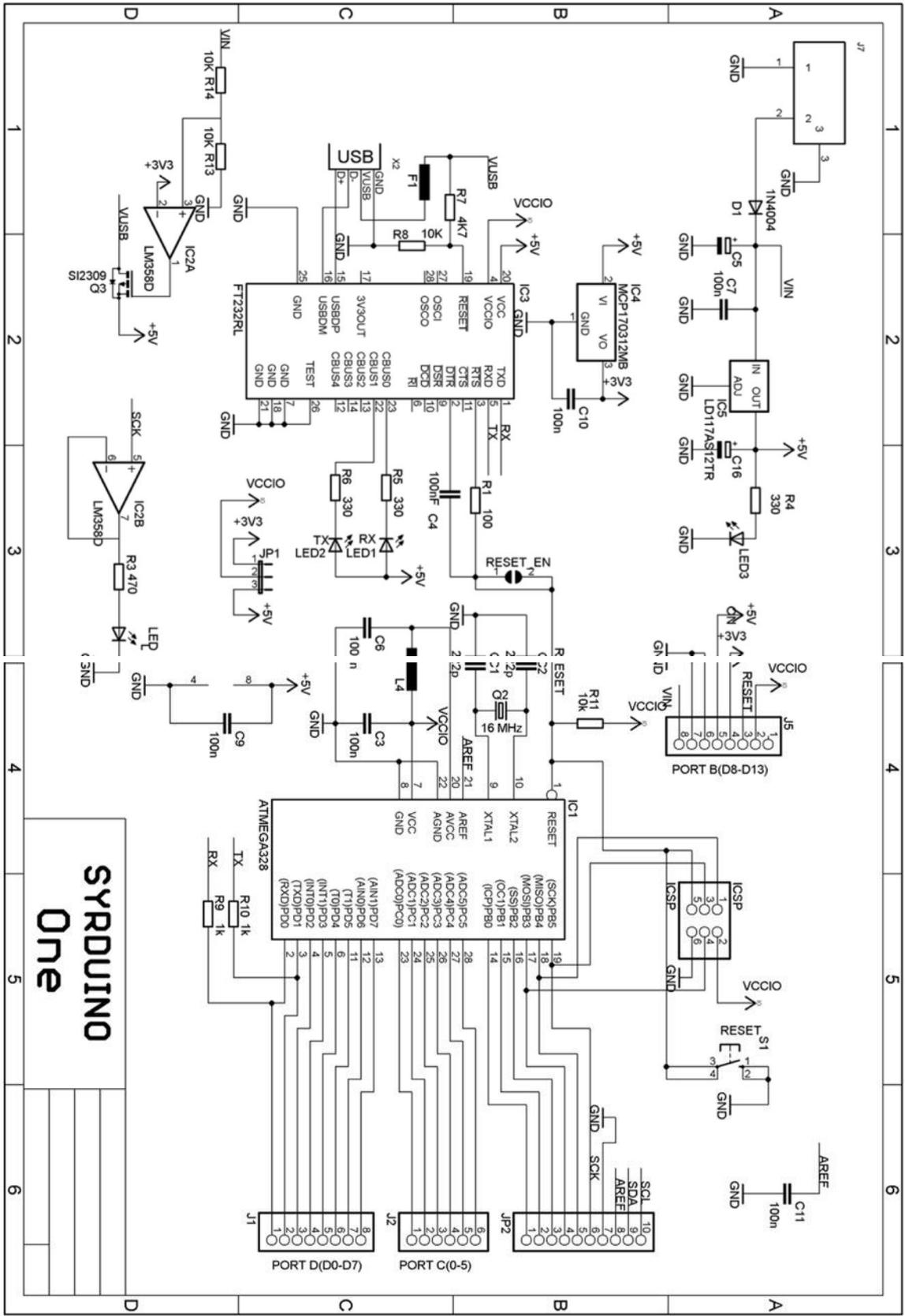
Appendix 3

ATMEGA328P

Microcontroller ATMEGA328P block diagram
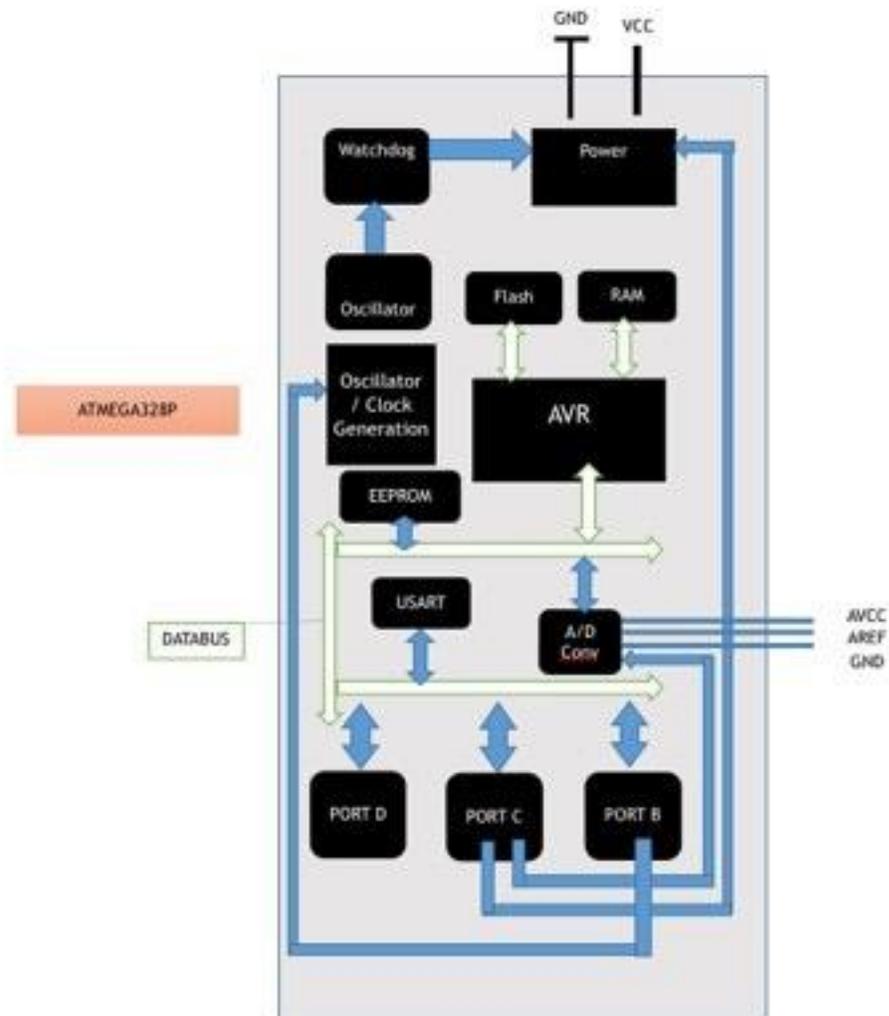
Features

• High Performance, Low Power AVR® 8-Bit Microcontroller

– Up to 20 MIPS Throughput at 20 MHz

High Endurance Non-volatile Memory Segments

–32K Bytes of In-System Self-Programmable Flash program memory (ATmega328P).

–1K Bytes EEPROM (ATmega328P).

–2K Bytes Internal SRAM (ATmega328P).

– Write/Erase Cycles: 10,000 Flash/100,000 EEPROM.

 Data retention: 20 years at 85°C/100 years at 25°C .

• Peripheral Features

– Two 8-bit Timer/Counters with Separate Pre scaler and Compare Mode. – One 16-bit Timer/Counter with Separate Pre scaler, Compare Mode, and Capture Mode .

– Real Time Counter with Separate Oscillator.

– Six PWM Channels.

– 8-channel 10-bit ADC.

– Programmable Serial USART.

– Programmable Watchdog Timer with Separate On-chip Oscillator. – On-chip Analog Comparator.

• Operating Voltage:

– 1.8 - 5.5V for ATmega328P.

• Temperature Range: – -
 40°C to 85°C.

• Speed Grade:

– 0 - 20 MHz @ 1.8 - 5.5V.

• Low Power Consumption at 1 MHz, 1.8V, 25°C for ATmega328P:

– Active Mode: 0.2 mA.

– Power-down Mode: 0.1 µA.

– Power-save Mode: 0.75 µA.

Pin Descriptions :
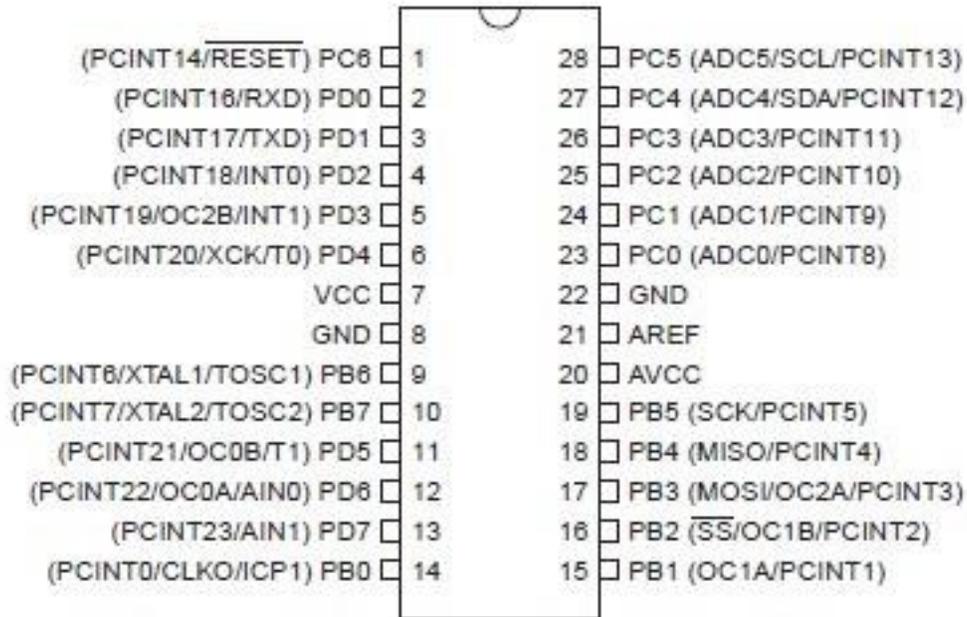
VCC:

Digital supply voltage.

GND: Ground.

Port B (PB7..PB0):

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each
bit). The Port B pins are tri-stated when a reset condition becomes active, even if the clock
is not running.

Port B also serves the functions of various special features of the ATmega328P.

Port C (PC7..PC0) Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit. The Port C pins are tri-stated when a reset

condition becomes active, even if the clock is not running. Port C also serves the functions of various specific features of the ATmega32

Port D (PD7..PD0) is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D pins are tri-stated when a reset condition

becomes active, even if the clock is not running.

Port D also serves the functions of various special features of the ATmega32

RESET:

 Reset Input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The minimum pulse length. Shorter pulses are not guaranteed to generate a reset.

XTAL1:

 Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2:

 Output from the inverting Oscillator amplifier.

AVCC:

 AVCC is the supply voltage pin for the A/D Converter. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter.

AREF: AREF is the analog reference pin for the A/D Converter.