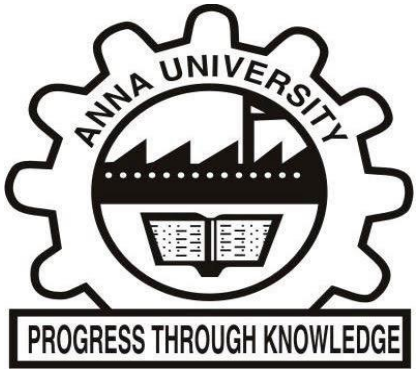
LIBRARY MANAGEMENT SYSTEM USING IMAGE PROCESSING



Submitted by

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OBJECTIVE

- The main purpose of our project is to provide an experimental system that will help library users to identify and locate the book needed in a faster and efficient way.
- This can also be used locate different items in a departmental stores.
- To minimise librarian work after book returns and to identify a misplaced book

LITERATURE SURVEY

REFERENCE NUMBER	OBJECTIVE AND METHODOLOGY	INFERENCE
[1]	Extraction of call numbers from the library books using connected component analysis,color segmentation and contour clustering for detection of alphanumeric area and using OCR for recognition.	Simple and memory efficient method,works well for slanted books but fails with books that have long call numbers and they are prone to multi-scale imagery.
[2]	Book identification was done using QR codes and barcodes present on the book spine.By using a line follower fitted with barcode scanner ,the location of the book is identified.	Low cost and reduced database size.Doesn’t work well for slanted books and non uniform lighting conditions

LITERATURE SURVEY

REFERENCE NUMBER	OBJECTIVE AND METHODOLOGY	INFERENCE
[3]	Book recognition is done by computing four directional edges and extracting it in a low resolution format and correlating with the features extracted from existing image in the database.	Free from noise and affine related problems. Requires more memory than other methods. Fails for the same book with different edition and books with damaged cover
[4]	Book cover identification is done using keypoint detection ,feature extraction and knn matching methods.DOG keypoint detector and SIFT feature descriptor is used.	Accurate matching providing scale invariance,rotation invariance and free from affine transformations. Not Memory efficient solution and has lot of computational complexity

PROJECT OUTLINE

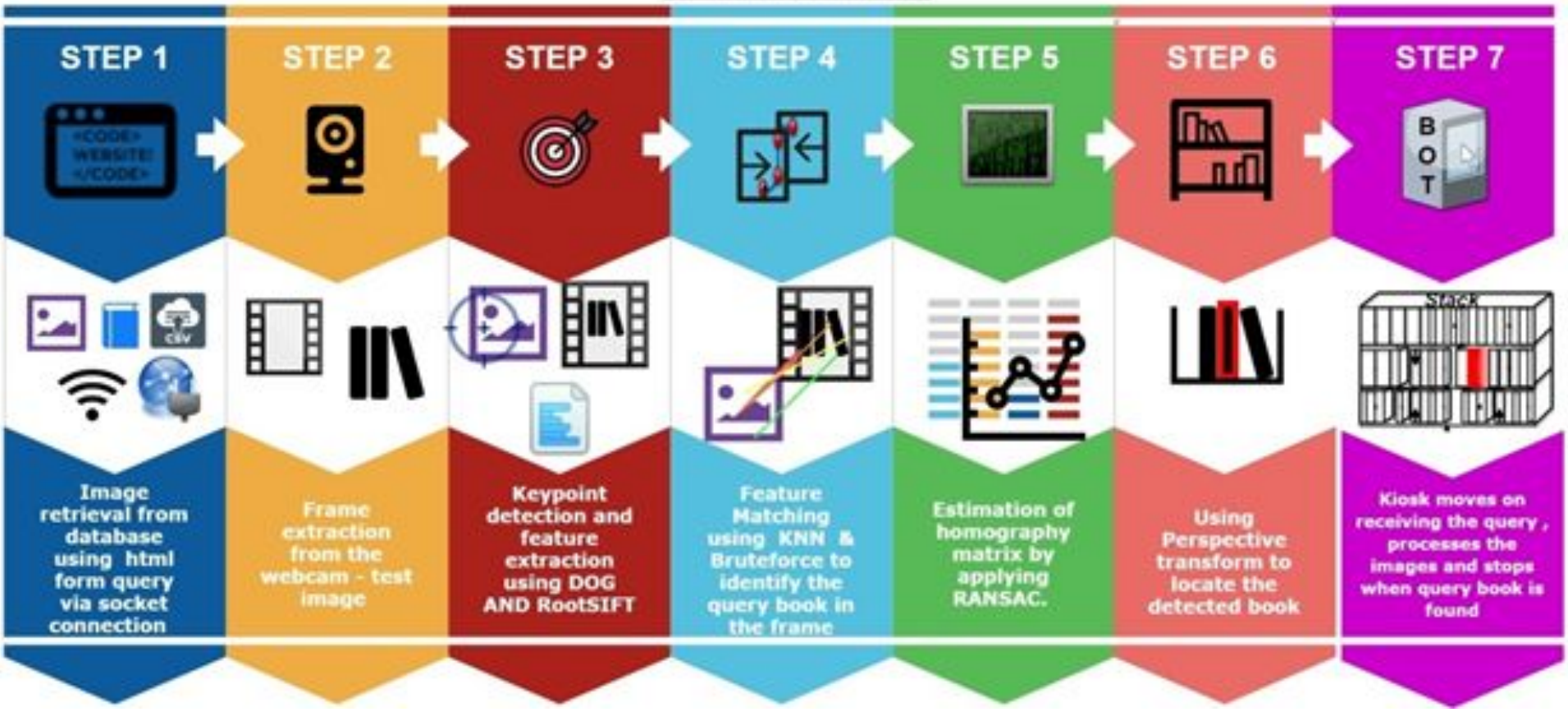
SOFTWARE BLOCK

- ALGORITHMS
  - USING MORPHOLOGICAL OPERATIONS(OCR BASED)
  - EDGE DETECTION [6]
  - FEATURE BASED TECHNIQUE
- SOCKET APP
- OPENCV, PYTHON

HARDWARE BLOCK

- KIOSK
  - RASPBERRY PI 3
  - ARDUINO
  - USB CAMERA
  - ULTRASONIC SENSOR

Workflow


STEP 1
STEP 2
STEP 3
STEP 4
STEP 5
STEP 6
STEP 7
<CODE>
WEBSITE
</CODE>
CSV
B
O
T
STATUS
Image retrieval from database using html form query via socket connection
Frame extraction from the webcam - test image
Keypoint detection and feature extraction using DOG AND RootSIFT
Feature Matching using KNN & Bruteforce to identify the query book in the frame
Estimation of homography matrix by applying RANSAC.
Using Perspective transform to locate the detected book
Kiosk moves on receiving the query , processes the images and stops when query book is found

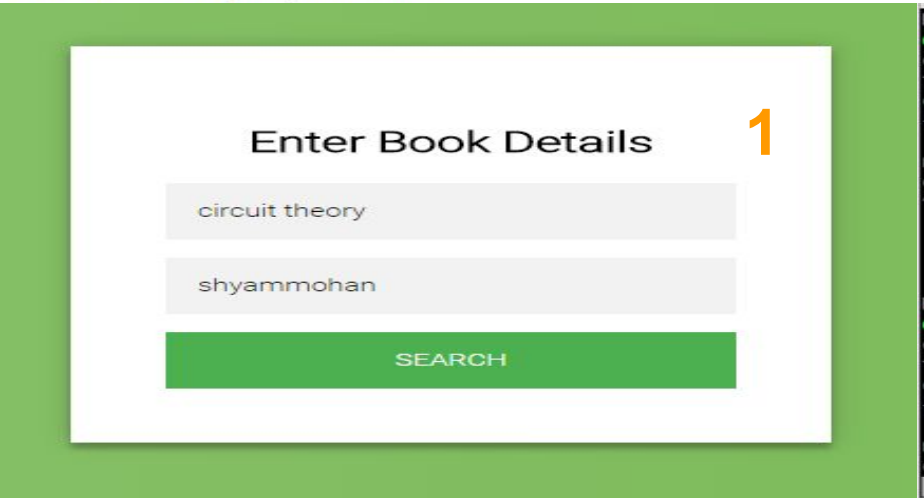
STEP 1

User gives input through the form → Socket Server is started in the Raspberry pi → The data from the user is sent to the server → Socket client on a servlet sends the parameters through the socket to the Raspberry pi → The Raspberry pi receives the values and picks the path of the image from the database.

1. Locally hosted web page-client
2. (request,acknowledgement)
3. Python server in raspberry pi 3

2

Done circuit theory#shyammohan



3

```
KeyboardInterrupt
odroid@odroid:~/Desktop/socketprog$ python server.py
client is at following address ('192.168.1.4', 3133)
the message is
circuit theory#shyammohan
{'a': 2, ' ': 1, 'c': 2, 'e': 1, 'i': 2, 'h': 3, 'm': 2, '#': 1, 'o': 2, 'n': 1,
 's': 1, 'r': 2, 'u': 1, 't': 2, 'y': 2} 25
no more messages to recv from client
closing client socket connection
^CTraceback (most recent call last):
  File "server.py", line 12, in <module>
    clientsock,addr=serversocket.accept()
  File "/usr/lib/python2.7/socket.py", line 202, in accept
    sock, addr = self._sock.accept()
KeyboardInterrupt
odroid@odroid:~/Desktop/socketprog$ python server.py
client is at following address ('192.168.1.4', 3137)
the message is
circuit theory#shyammohan
{'a': 2, ' ': 1, 'c': 2, 'e': 1, 'i': 2, 'h': 3, 'm': 2, '#': 1, 'o': 2, 'n': 1,
 's': 1, 'r': 2, 'u': 1, 't': 2, 'y': 2} 25 ['circuit theory', 'shyammohan']
no more messages to recv from client
closing client socket connection
```

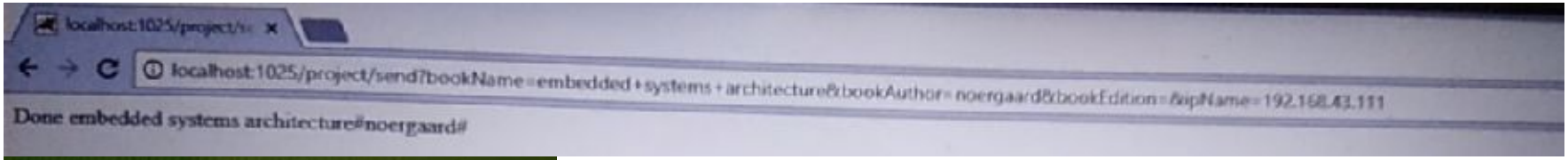
Query with Database

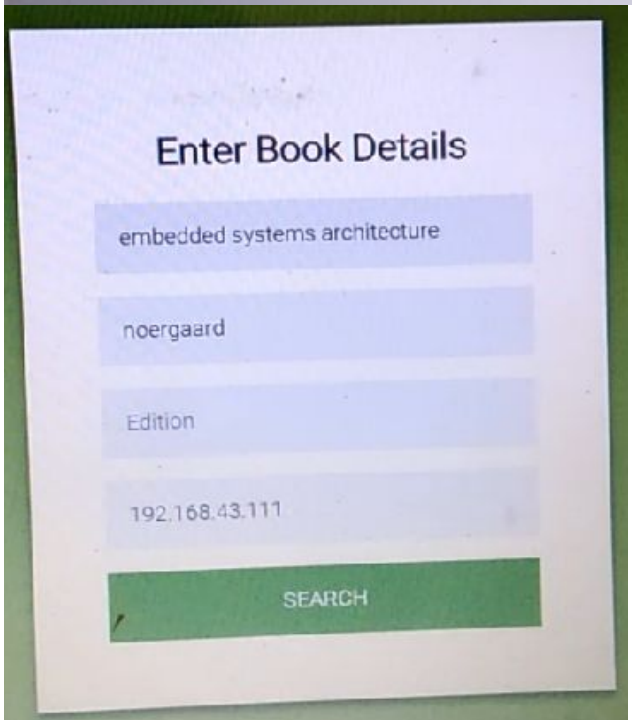
- Reading data from a csv file..
- Retrieving the image path of the query book based on the locally data sent.
- Books are cropped, such that their spine fits the entire frame

```
C#,XAVIER,,1.jpg
ENGINEERING PHYSICS,MUKHERJI,,2.jpg
ENGINEERING ELECTROMAGNETICS,HAYT,FIFTH,3.jpg
A TEXTBOOK ON C#,MURUGESAN,,4.jpg
MATHEMATICAL ANALYSIS,APOSTO,,5.jpg
ENGINEERING MATHEMATICS-II,VEERARAJAN,,6.jpg
OPERATING SYSTEMS,NIIT,,7.jpg
AIRCRAFT MATERIALS & PROCESSES,,FIFTH,8.jpg
ELECTRICAL ENGINEERING,HAMBLEY,SECOND,9.jpg
AN EMBEDDED SOFTWARE PRIMER,SIMON,,10.jpg
INTERNAL COMBUSTION ENGINE FUNDAMENTALS,HEYWOOD,,11.jpg
THE AUTOMOTIVE CHAS,GENTA,,12.jpg
DEFORMATION AND FRACTURE MECHANICS,HERTZBERG,FOURTH,13.jpg
CERAMIC PRECURSOR TECHNOLOGY,NARULA,,14.jpg
WAVELETS IN ELECTROMAGNETICS AND DEVICE,PAN,,15.jpg
HOW TO MAKE INJECTION MOLDS,MOHREN,,16.jpg
SUPERCONDUCTIVITY,BUCKEL,,17.jpg
PROBABILITY MODELS IN OPERATIONS RESEARCH,CASSADY
NACHLAS,,18.jpg
FUEL CELL FUNDAMENTALS,COLELLA,,19.jpg
TYRE AND VEHICLE DYNAMICS,PACEJKA,,20.jpg
COMPLEX ANALYSIS WITH MATHEMATICA,SHAW,,21.jpg
POLYMER MATRIX COMPOSITES AND TECHNOLOGY,WANG,,22.jpg
BRITANNICA,,,23jpg
VOICE OVER PACKET NETWORKS,WRIGHT,,24.jpg
ANALYTICAL INSTRUMENTATION,CURRELL,,25.jpg
INTELLECTUAL PROPERTY RIGHTS,GANGULI,,26.jpg
IMAGE PROCESSING FOR COMPUTER GRAPHICS,VELHO,,27.jpg
MECHANICAL PROPERTIES OF POLYMERS,MICHLER,,28.jpg
LINUX COMPANION FOR SYSTEM ADMINISTRATORS,HEIN,,29.jpg
```

CSV file with fields for book name,author name, edition and image path

STEP 1 (query image retrieval)

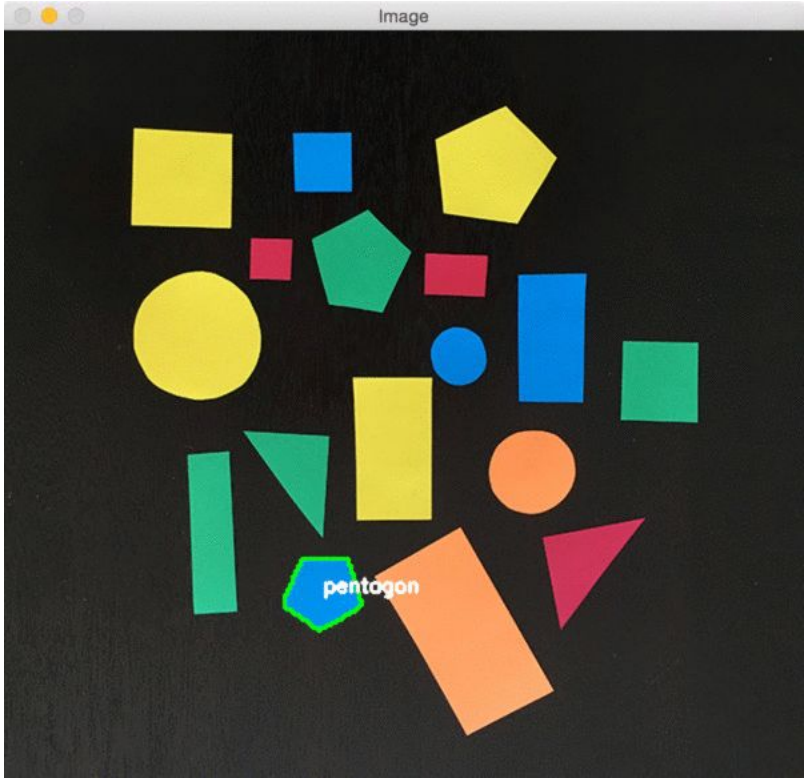




STEP 2 (test image from (iBall)webcam)

Keypoint Identification and Feature Extraction

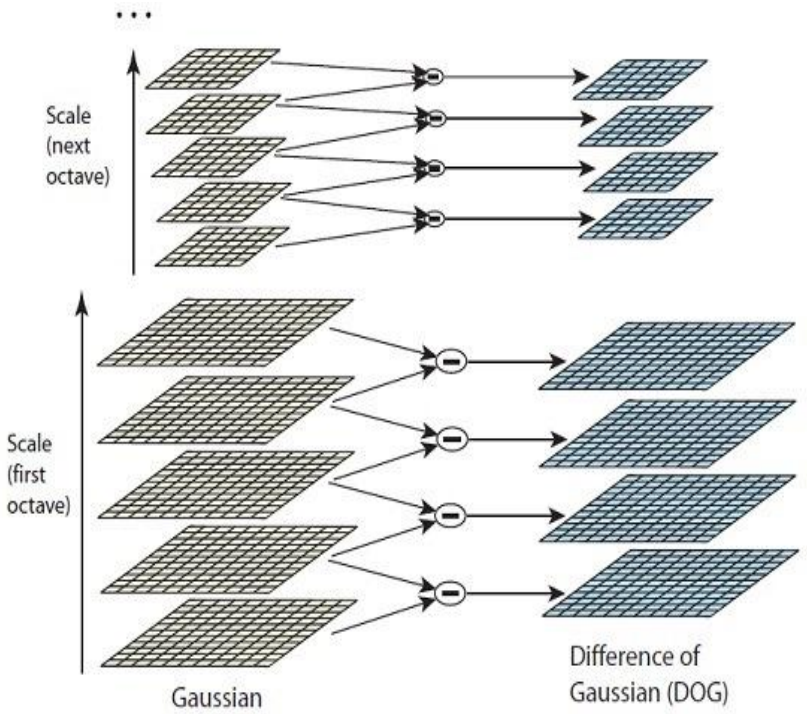
- Feature extraction is nothing but the process of quantifying an image and characterising it based on texture, colour, shape or combination of all three.The output of feature extraction process is a feature vector representing an entire image (image descriptor)or local region in an image(feature descriptor).
- Keypoint detection involves locating interest points around which feature descriptors can be constructed.
- Good keypoint detector should produce repeatable and localised keypoints for precision matching.



DOG Keypoint Detection

- DoG keypoint detector which works perfectly in detecting book spines in different orientation and scales.

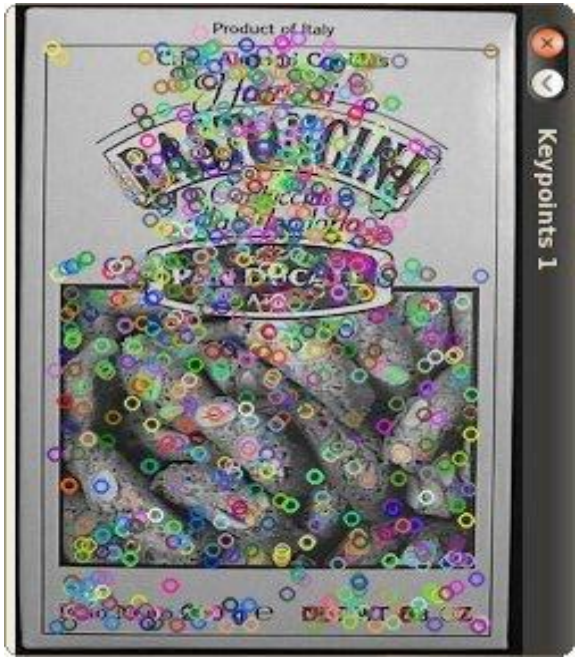
- DoG makes use of scale space where an octave(set of column images with same size) consisting of different versions of same image but gaussian blurred to different extent in each stage of that octave



Keypoint Detection and Feature extraction in book spine

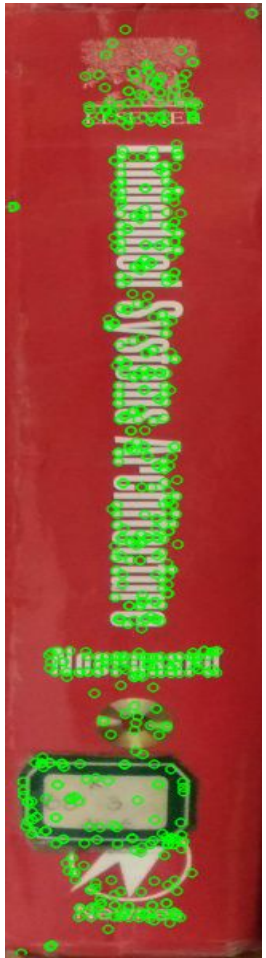
- In our case we use feature extraction to identify interesting regions of specific book spine and extract features from them and later use those features to compare the books present in the library stack.

- There are several keypoint detectors like MSER, FAST, HESSIAN, HARRIS,STAR,DENSE but DOG (SIFT) keypoint detector found to perform well for this problem with minimum false positives.



Keypoint detection in front cover.

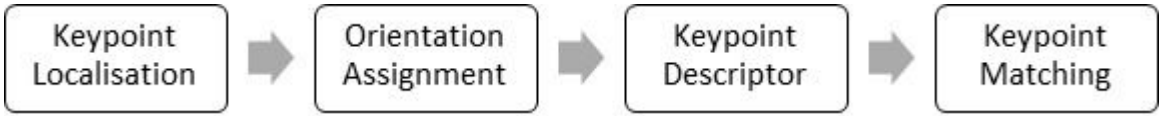
STEP 3 - KEYPOINT DETECTION

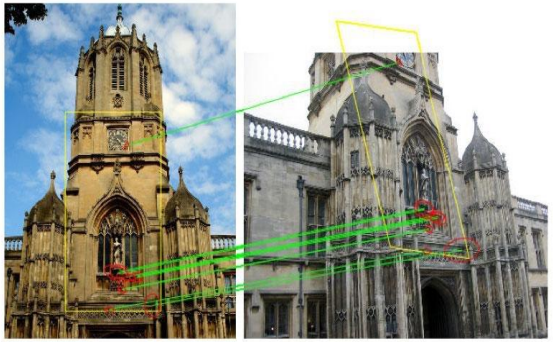


QUERY IMAGE KEYPOINTS AND TEST IMAGE KEYPOINTS

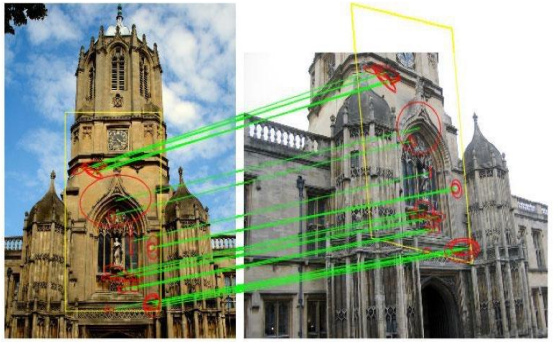
SIFT and RootSIFT Feature Description

- SIFT uses HOG to create 128 dimension vector.
- ROOTSIFT[5] which is a simple extension to SIFT feature descriptor.We modify the SIFT in such a way that when the feature vectors are measured with same old euclidean distance they appear to be measured with hellinger kernel.
- ROOTSIFT outperforms SIFT in terms of number of accurate keypoint matches.





(a) SIFT (L2 distance): 10 matches



(b) RootSIFT: 26 matches

NORMALIZATION

L1-norm is also known as least absolute deviations (LAD), least absolute errors (LAE). It is basically minimizing the sum of the absolute differences **(S)** between the target value ($\mathbf{Y_i}$) and the estimated values ($\mathbf{f(x_i)}$):

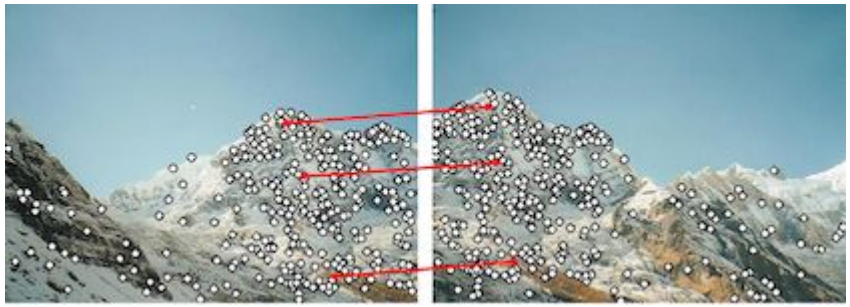
$$S = \sum_{i=1}^{n} |y_i - f(x_i)|.$$

L2-norm is also known as least squares. It is basically minimizing the sum of the square of the differences **(S)** between the target value ($\mathbf{Y_i}$) and the estimated values ($\mathbf{f(x_i)}$):

$$S = \sum_{i=1}^{n} (y_i - f(x_i))^2$$

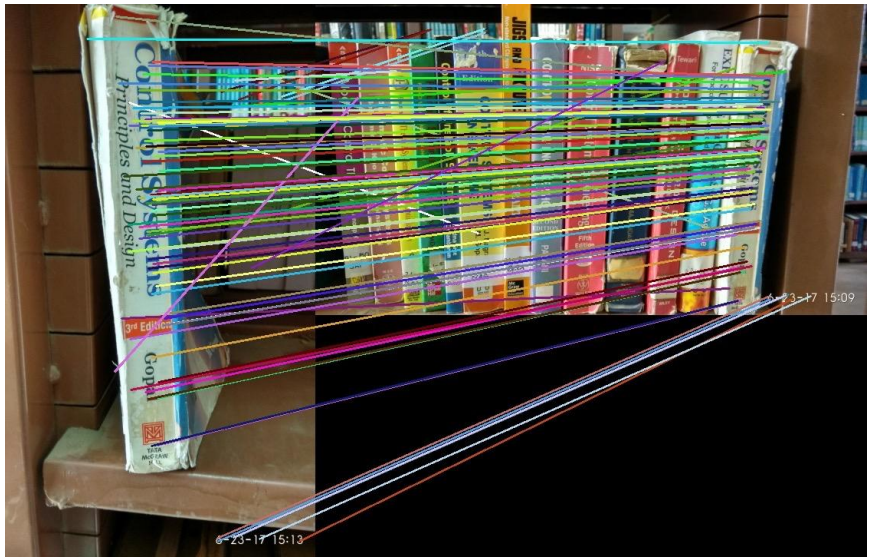
Feature Matching

- Feature matching is done using any of the distance algorithm which hunts for similarity between points of two different images (maximum likelihood).



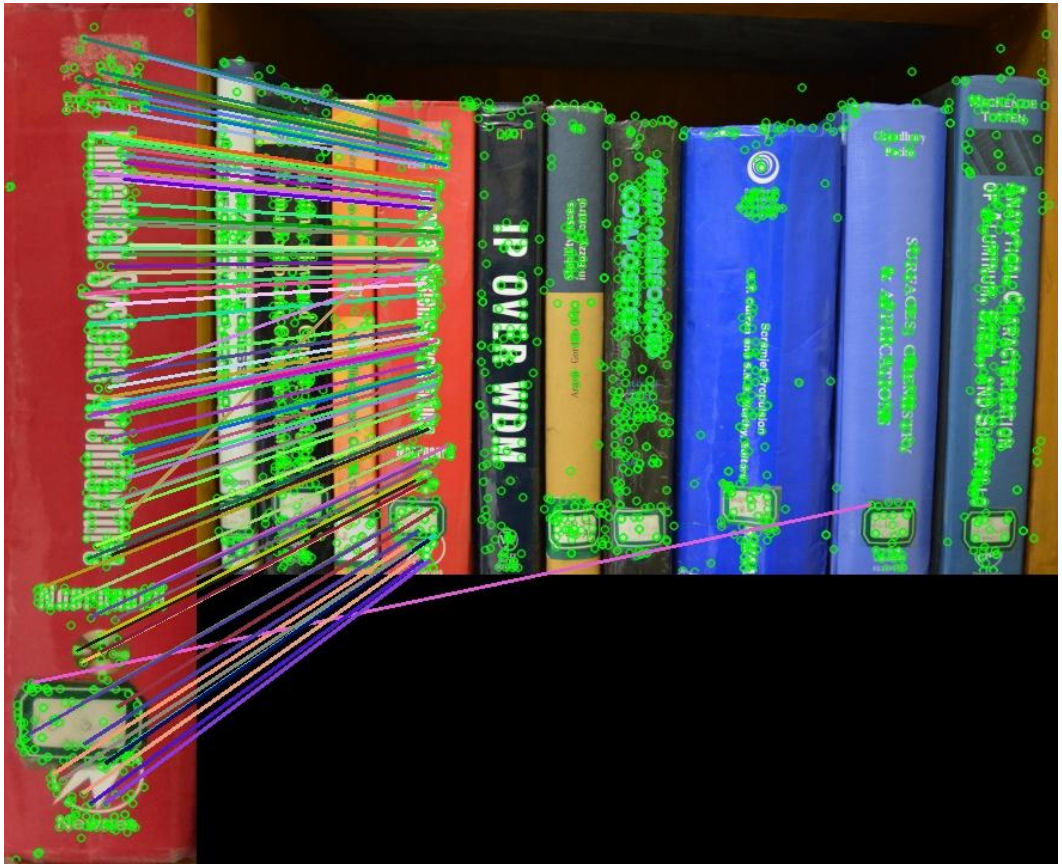
- The accuracy in finding matched keypoints between two images lies in the distance computation algorithm and the way it has been used.

- Here K-nearest neighbour algorithm along with Lowe's ratio test is used to find reliable and accurate matches to the keypoints in query image.



Result of applying Lowe's ratio test and Knn algorithm

- The K nearest neighbour (Knn) method is used to identify at least two nearest neighbours(in this case)closer to the matched keypoint.
- Lowe's ratio is based upon the fact that the neighbours of matched keypoints are always farther.By making lowe ratio to be 0.7,we could achieve accuracy by eliminating outliers.

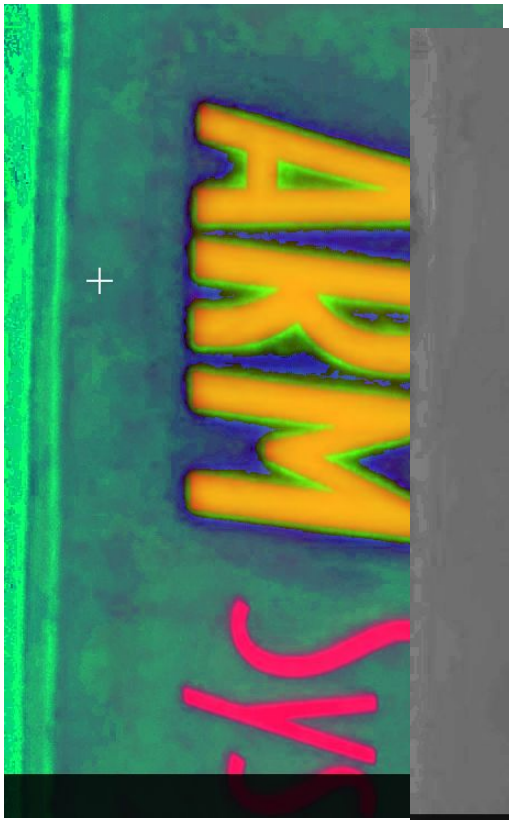


```
C:\Users\rs saai magesh\Desktop\project final yr\integration and testing>python draw_matches.py --first change.jpeg --se
cond test3.jpg --output matchsloss.png --detector SIFT --extractor RootSIFT
descriptor shape:    (363, 128)
summed shape: (363, 1)
final shape of descp: (363, 128)
descriptor shape:    (3211, 128)
summed shape: (3211, 1)
final shape of descp: (3211, 128)
# of keypoints from first image: 363
# of keypoints from second image: 3211
# of matched keypoints: 174
```

Color feature descriptor

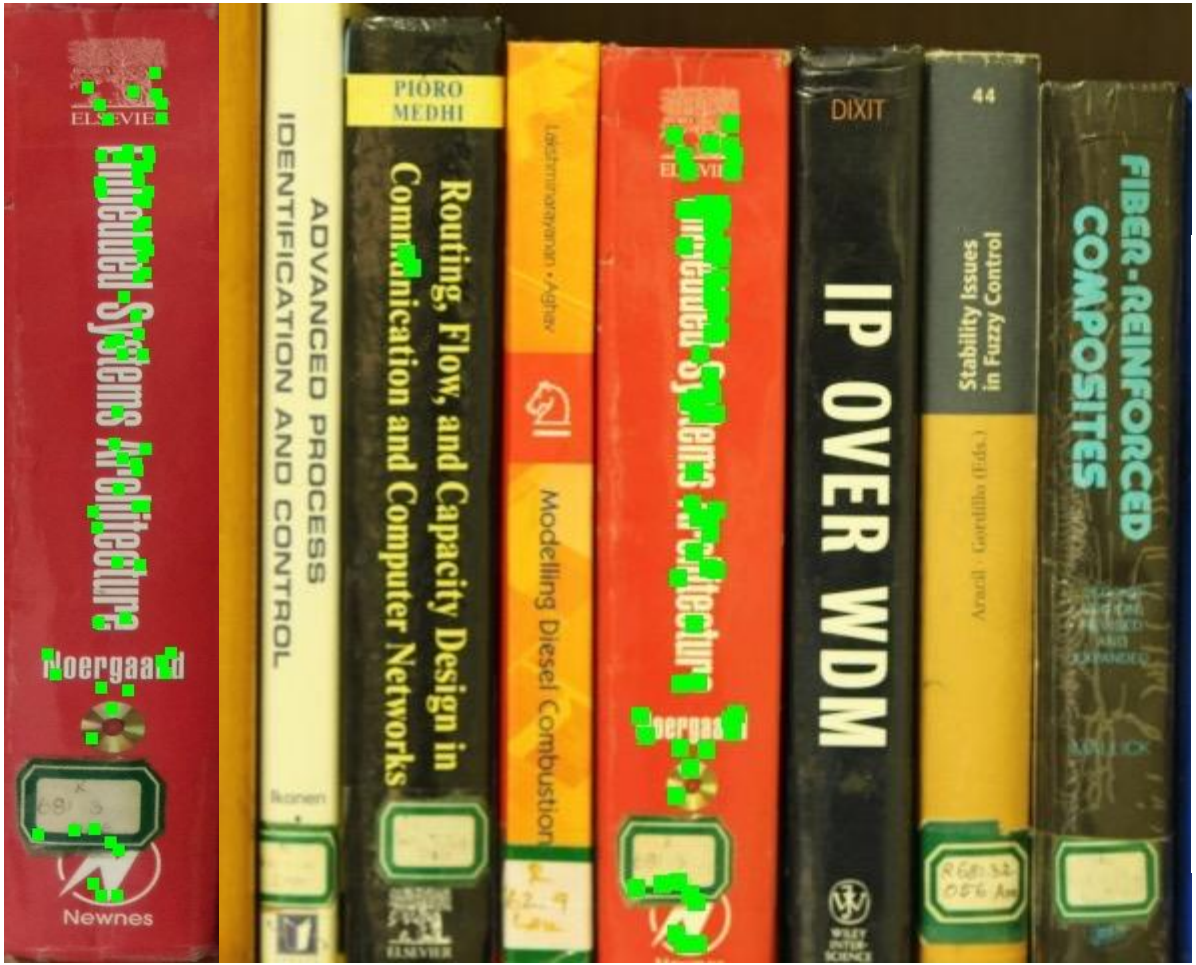
- Compute a 9X9 rectangular window around the keypoint and convert both images to hsv space.
- Calculate histogram around these widows in Hue plane.
- Append all the vectors and compute euclidean distance between them.
- Threshold the matches based on the color similarity and send those matches to homography

HSV Image

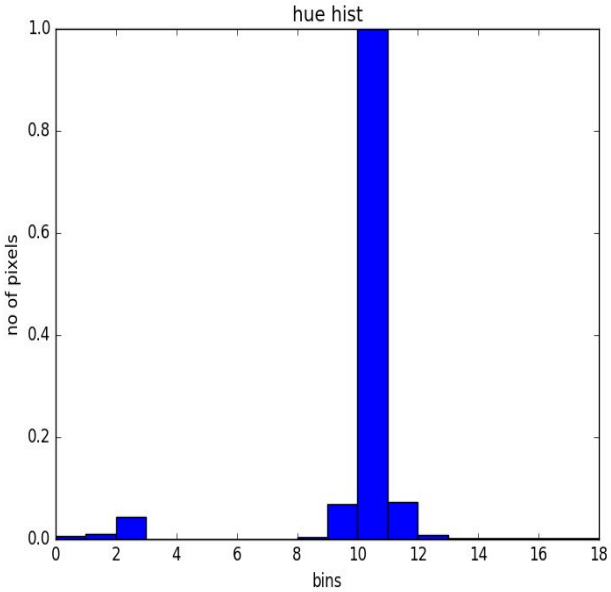


Hue Only Image

Window of 9X9 size around the matched keypoints in both query and test image



Hue Histogram around these keypoints



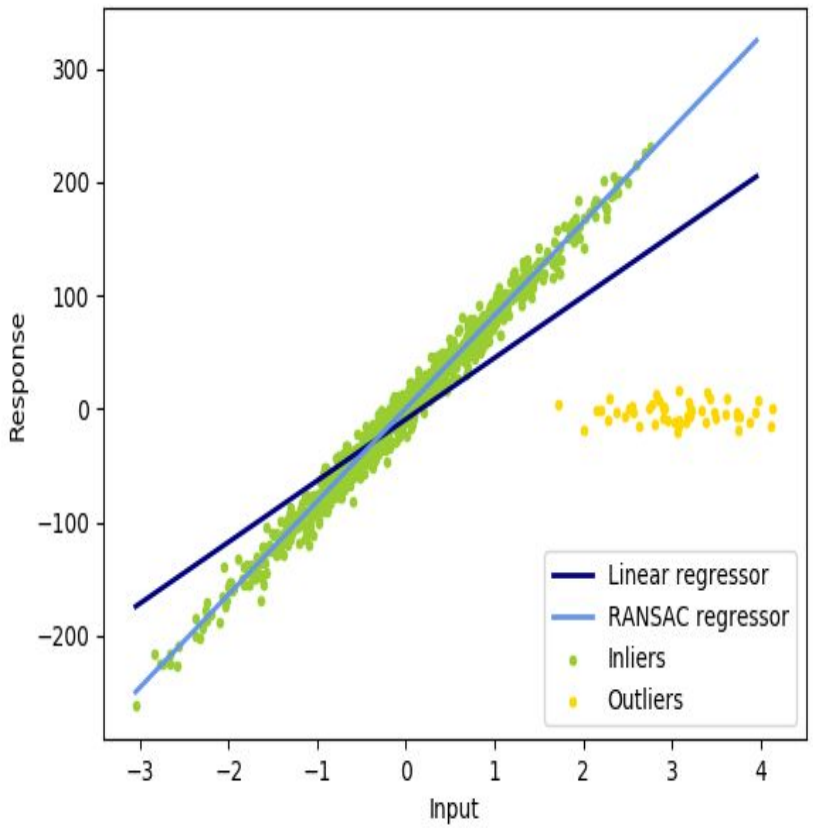
Homography Estimation

- A Homography is a transformation (a 3×3 matrix) that maps the points in one image to the corresponding points in the other image.

RANSAC

- Random Sample Consensus assumes that the training data consists of inliers that can be explained with the model and outliers that don't fit the model at all.

- RANSAC needs a model for the data along with cost function, number of sample points in a set,threshold for outlier rejection



Ransac along with Homography

- Applying Ransac in homography matrix computation to eliminate the outliers.Ransac works with an estimation model and cost function just like linear regression.Here the estimation model is the homography matrix.
- To compute this accurately a threshold for allowing amount of outliers has to be specified in before.
- **Cost function:**

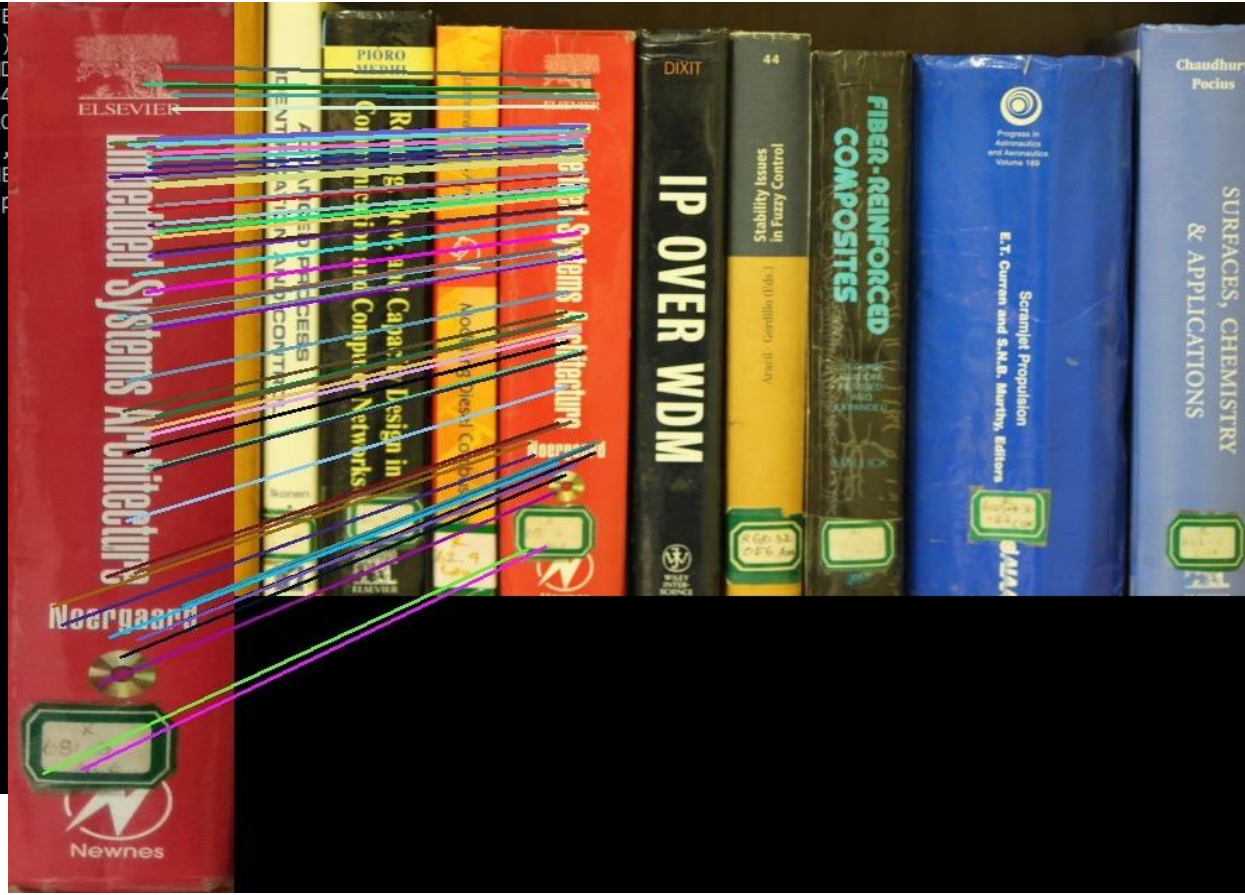
$$\left\| \text{dstPoints}_i - \text{convertPointsHomogeneous}\left(H * \text{srcPoints}_i\right) \right\| > \text{ransacReprojThreshold}$$

If this is true the point i is rejected as a outlier ,for homography computation maximum of four matching points is enough,for accurate matching,model with more inliers is taken

Result of Ransac based homography computation and matching

```
DMA', 'IPATOV', ''), '81.jpg': ('EMBEDDED SYSTEMS ARCHITE
A', 'SHAW', ''), '57.jpg': ('GAS TURBINES', 'SOARES', '')
 'WILLIAMS', ''), '68.jpg': ('AIRCRAFT AEROELASTICITY AND
, ''), '48.jpg': ('ENGINE COMBUSTION', 'ROGERS', ''), '64
ECHANICS', 'HERTZBERG', 'FOURTH'), '72.jpg': ('SIGNAL PRO
'83.jpg': ('FIBER-REINFORCED COMPOSITES', 'MALLICK', ''),
CTURE DESIGN', 'MALEN', ''), '9.jpg': ('ELECTRICAL ENGINE
'), '17.jpg': ('SUPERCONDUCTIVITY', 'BUCKEL', ''), '69.jp
KA', '')}
descriptor shape:    (605, 128)
summed shape: (605, 1)
final shape of descp: (605, 128)
descriptor shape:    (2801, 128)
summed shape: (2801, 1)
final shape of descp: (2801, 128)
BOOK is not present in the frame - 7/11
descriptor shape:    (2881, 128)
summed shape: (2881, 1)
final shape of descp: (2881, 128)

# of keypoints from first image: 605
# of keypoints from second image: 2881
# of matched keypoints: 82
score:
0.841463414634
false positives 13
accurate matches 69
descriptor shape:    (4051, 128)
summed shape: (4051, 1)
final shape of descp: (4051, 128)
```



Ransac outlier elimination threshold 4.

Perspective Transform

- Perspective transform helps to find correspondence points between two images.
- We perform Perspective transform which calculates the amount of rotation, translation needed for identifying the corner coordinates in the test image.
- With the help of homography matrix, it computes the coordinates of the book spine.

$$H = \begin{bmatrix} h_{00} & h_{01} & h_{02} \\ h_{10} & h_{11} & h_{12} \\ h_{20} & h_{21} & h_{22} \end{bmatrix} \qquad \begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = H \begin{bmatrix} x_2 \\ y_2 \\ 1 \end{bmatrix} = \begin{bmatrix} h_{00} & h_{01} & h_{02} \\ h_{10} & h_{11} & h_{12} \\ h_{20} & h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} x_2 \\ y_2 \\ 1 \end{bmatrix}$$

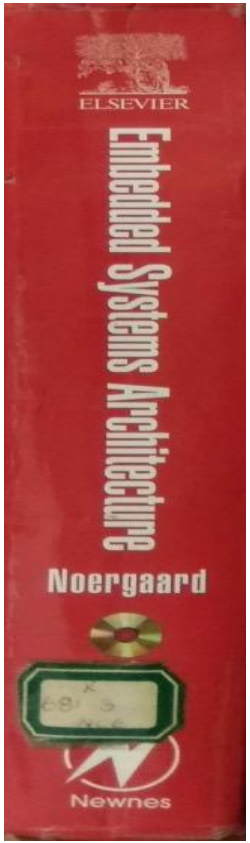
Homography Matrix obtained from matched keypoints

Unknown book corner coordinates

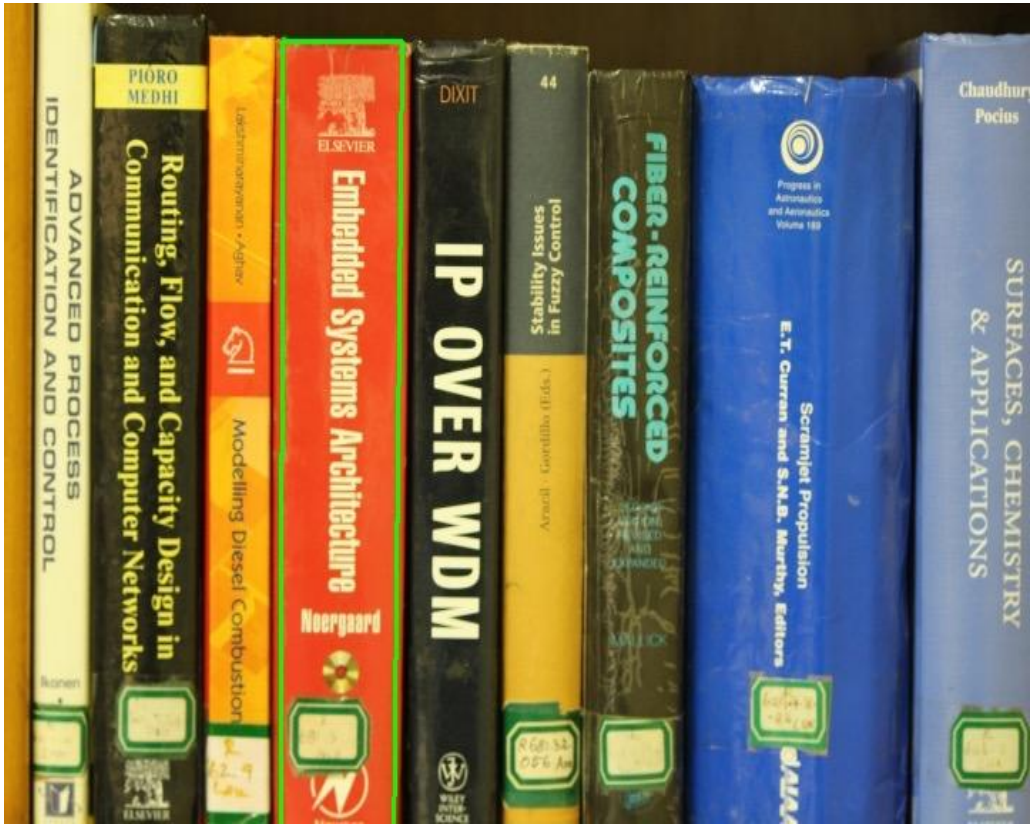
Cropped image corner coordinates

Bounding Box and Book Detection

After detecting the coordinates we draw the bounding box around the book in the test frame



Query Image



Test Image with bounding box(green)

Merits and Demerits

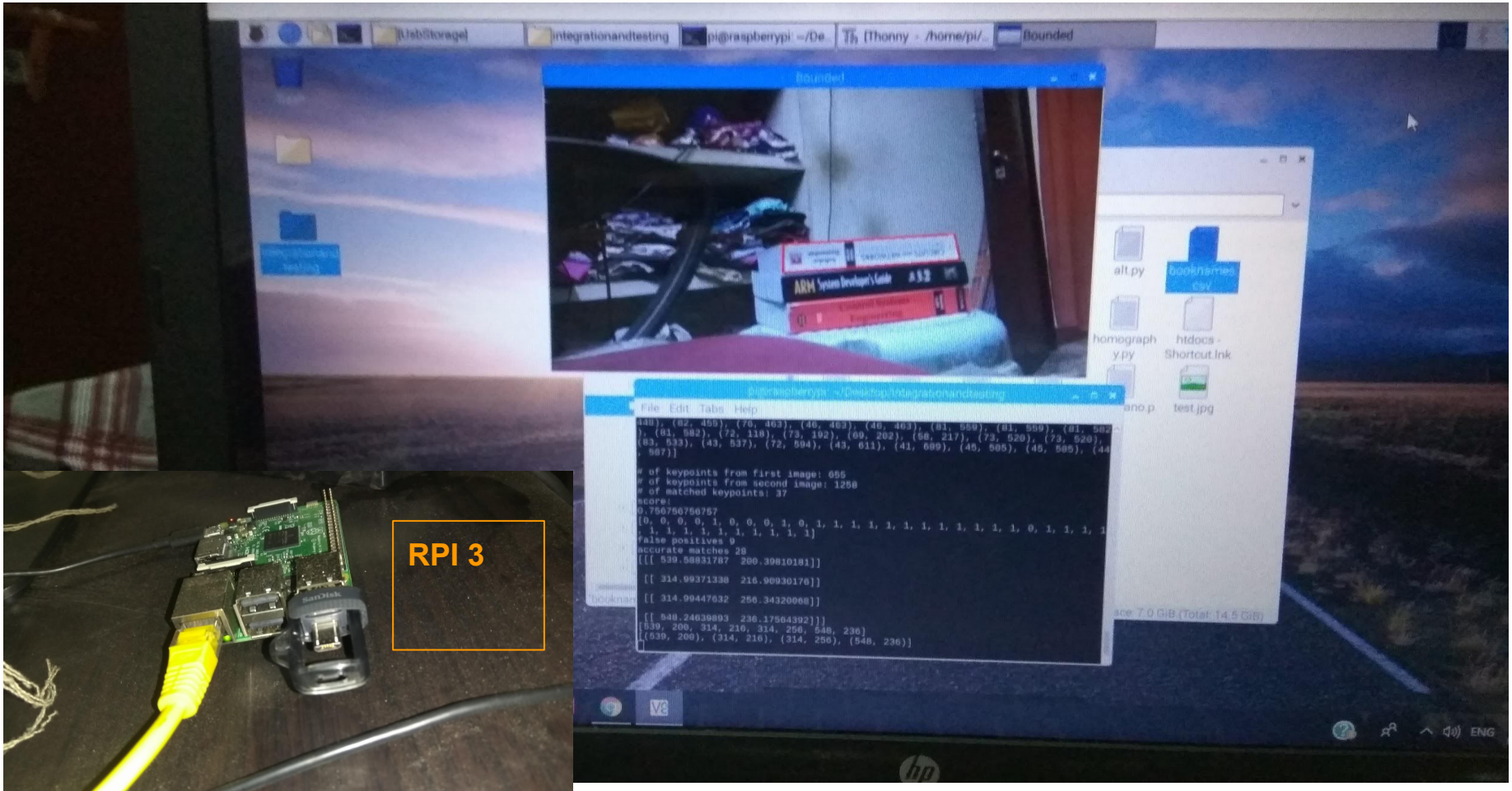
Merits:

- Only one image is required to identify any book.
- Computationally less expensive than machine learn based algorithm.
- Scale, affine, viewpoint, illumination, translation invariant.

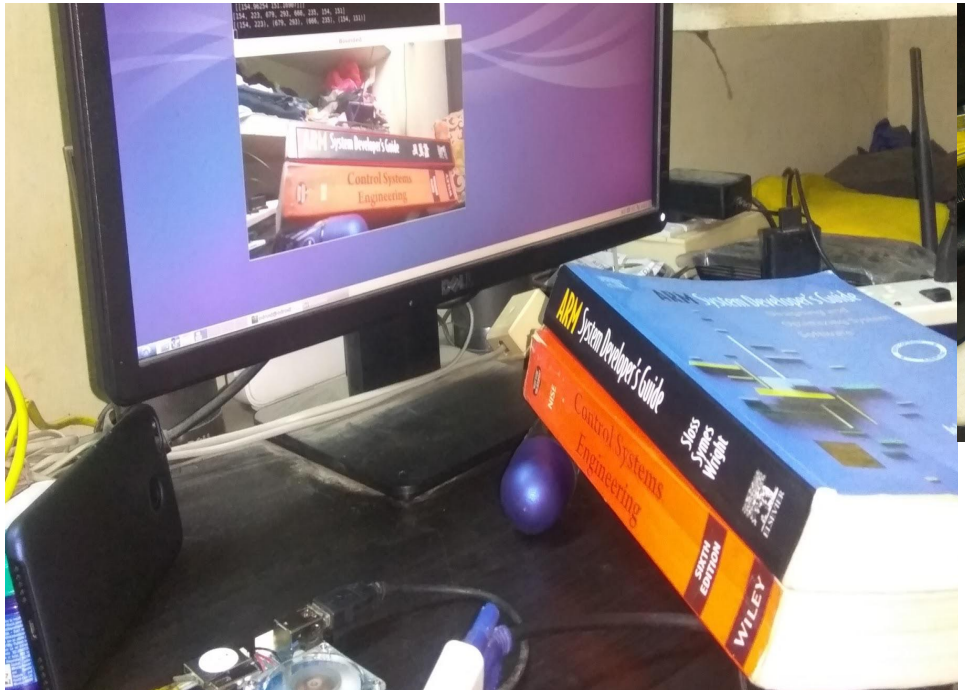
Demerits:

- Not hardware friendly algorithm.
- Less Ram based SBC suffers to run.
- Fails to identify same books of different edition since it is not based on ocr.

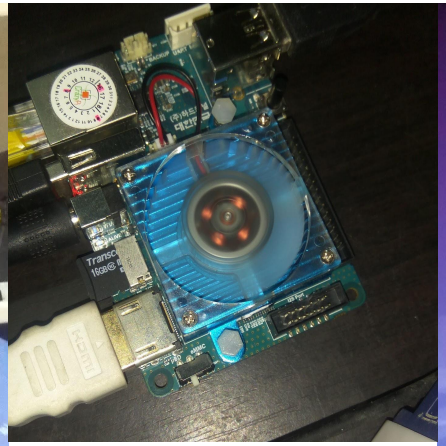
Initial Hardware Testing - Low end SBC



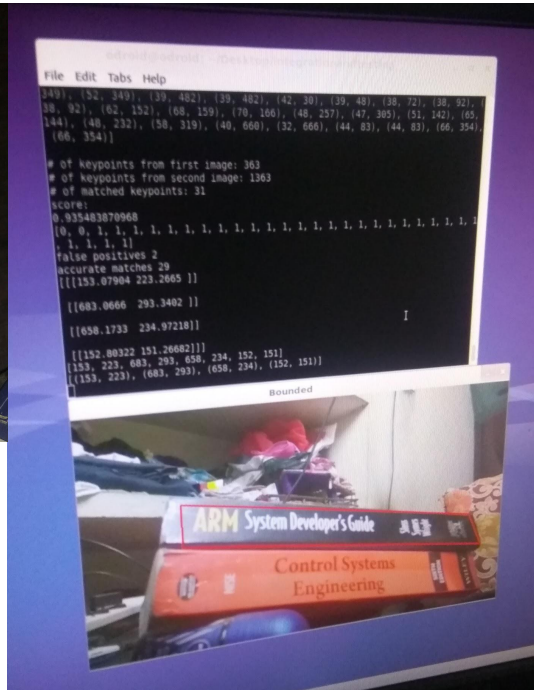
Initial Hardware Testing - High performance SBC



SOCKET BASED CAMERA CONNECTION



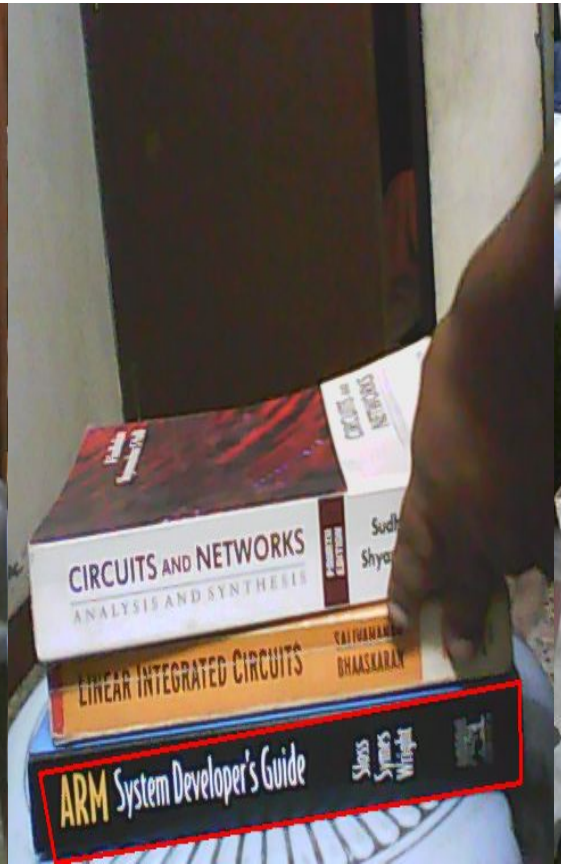
ODROID XU4



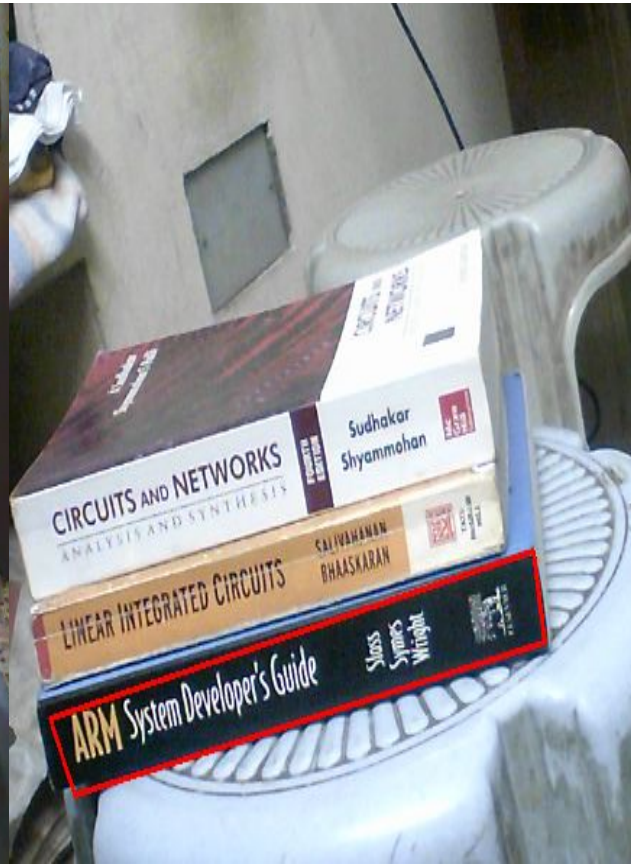
BOOK DETECTION (RED LINE)

PROPER SELECTION OF WEB CAMERA

GENIUS (LEFT)

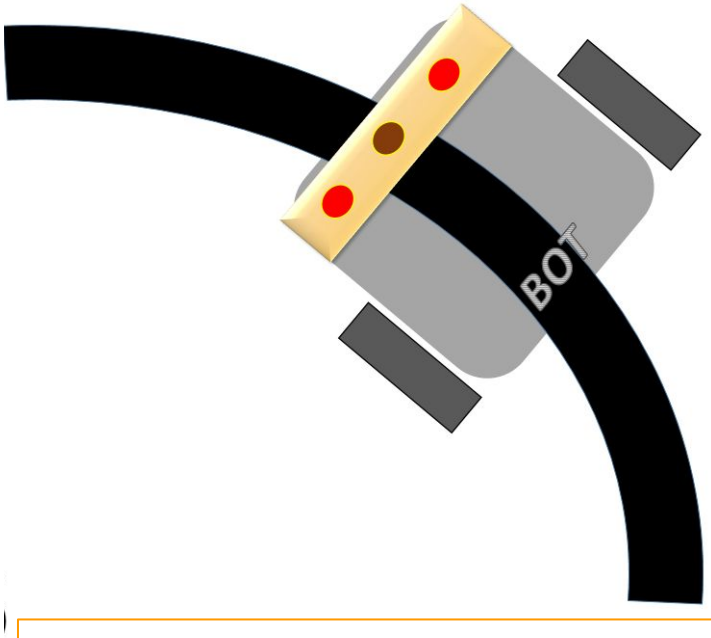


LOGITECH (CENTER)

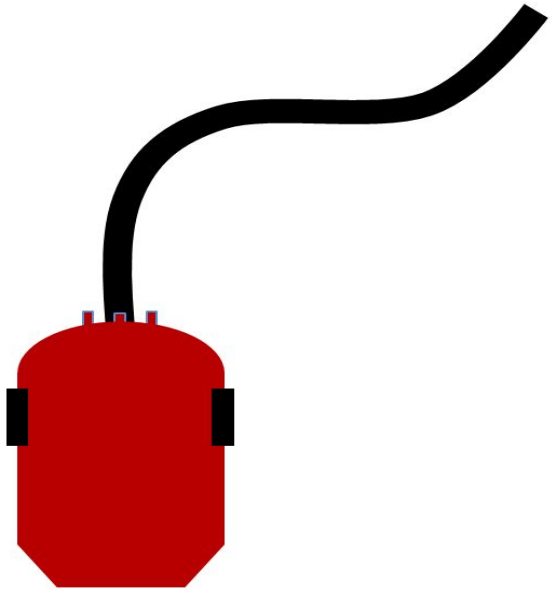


IBALL WEBCAM CHD20

LINE FOLLOWER DESIGN



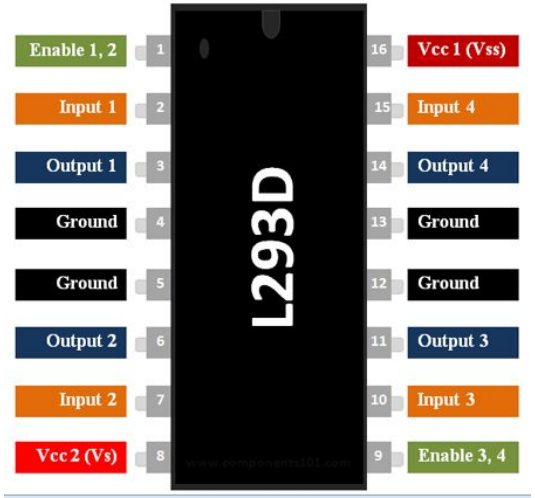
PATH HAS LEFT TURN - BOT TAKES LEFT TURN - LEFT MOTOR MOVES REVERSE - RIGHT MOTOR MOVES FORWARD

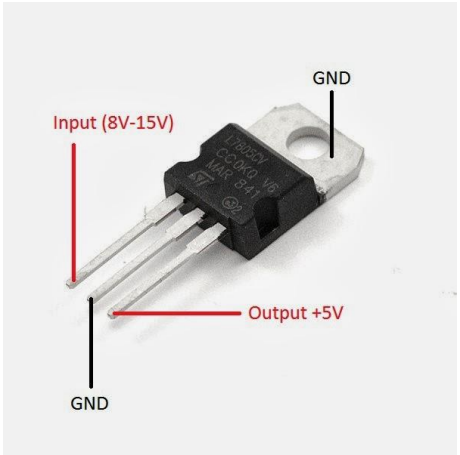


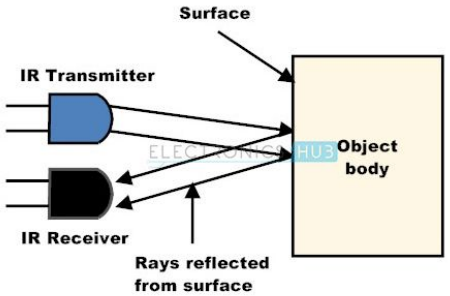
PATH HAS RIGHT TURN - BOT TAKES RIGHT TURN - LEFT MOTOR MOVES FORWARD - RIGHT MOTOR MOVES REVERSE

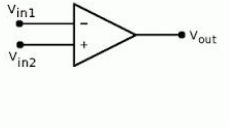
COMPONENTS USED

- Motor 200 RPM
- L293D Motor Driver IC
- 9V Battery 1.2Ah (Lead Acid)
- iBALL CHD 20.0
- Raspberry Pi 3
- Arduino UNO - Atmega 328
- LM7805
- Breadboard
- USB to TTL wire
- Line follower chassis along with wheels
- Double side Tape





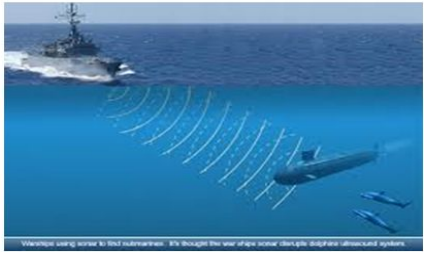


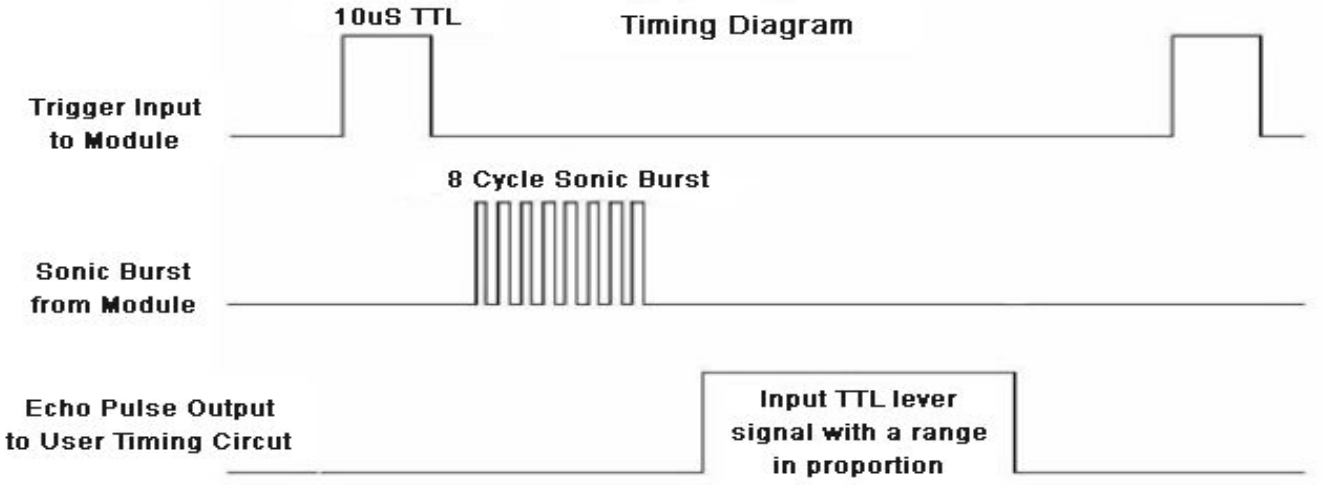


Ultrasonic Sensor

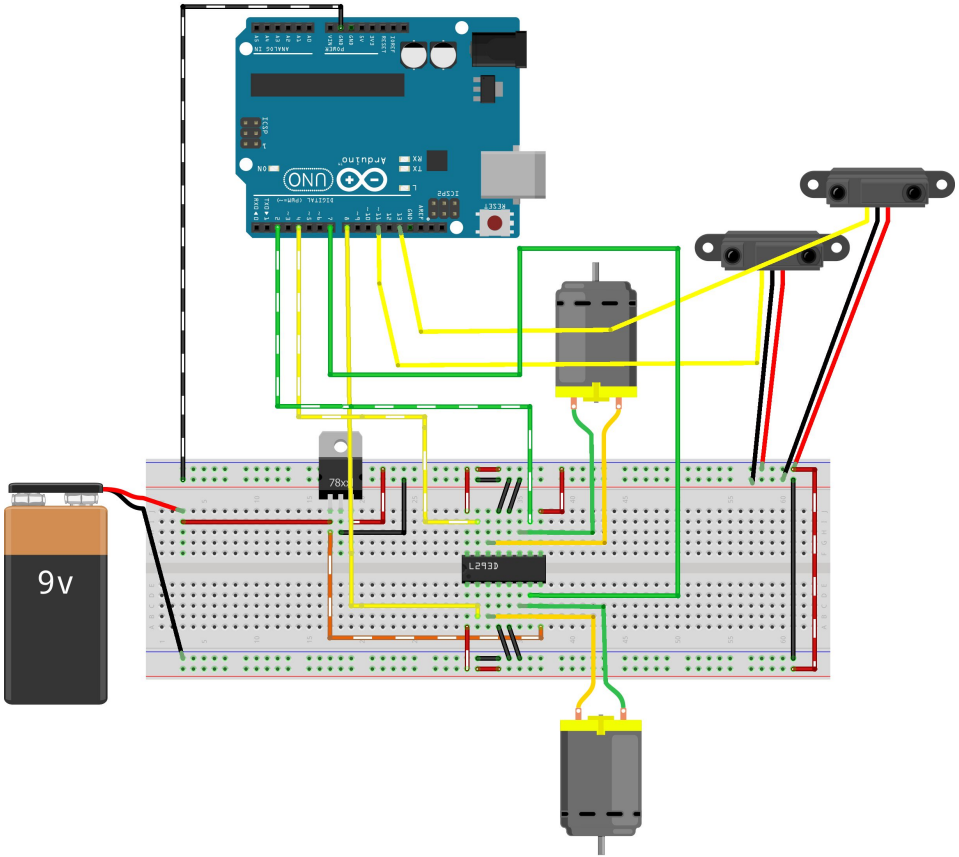
Distance (in cm)= (speed of sound(m/s) X duration of pulse (in microseconds))/2

Distance (in cm)= duration of pulse (in microseconds)/58





LINE FOLLOWER CIRCUIT



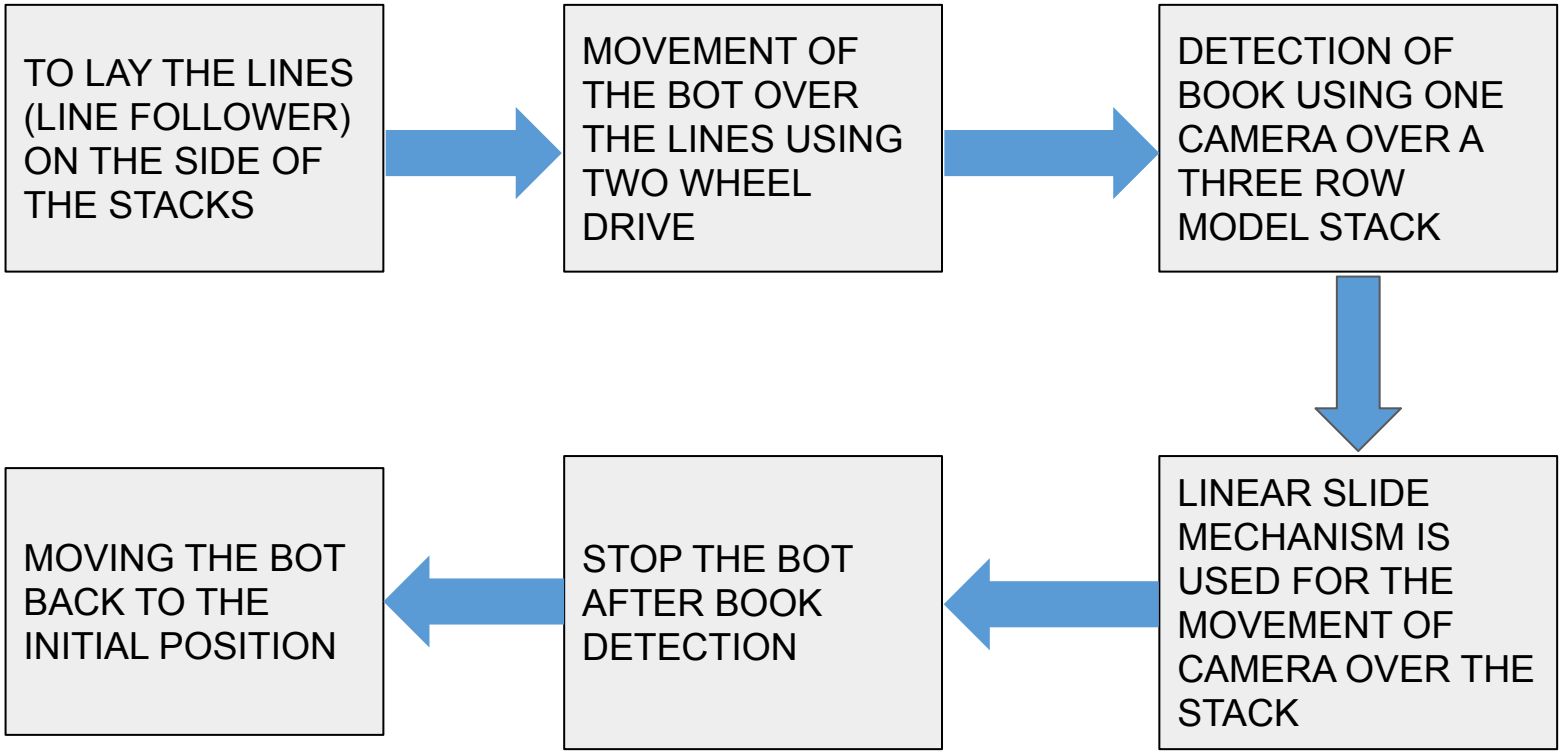
LINE FOLLOWER IMPLEMENTATION

Line follower test track along with test stack

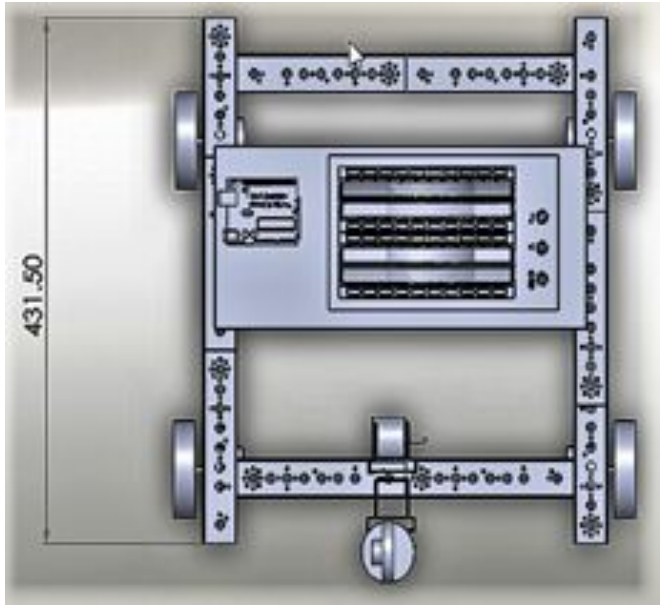
LINE FOLLOWER IMPLEMENTATION

Line Follower Hardware Model (top view) and (front view)

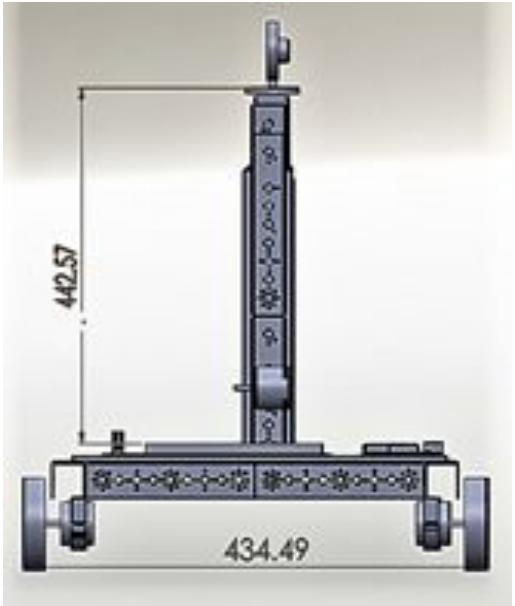
GENERAL BOT / MOVING KIOSK DESIGN



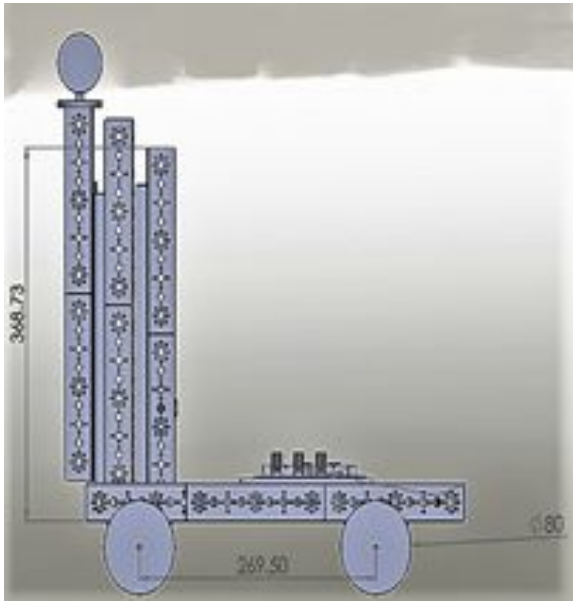
CAD Modelled Design of the Bot/Moving Kiosk



Top View

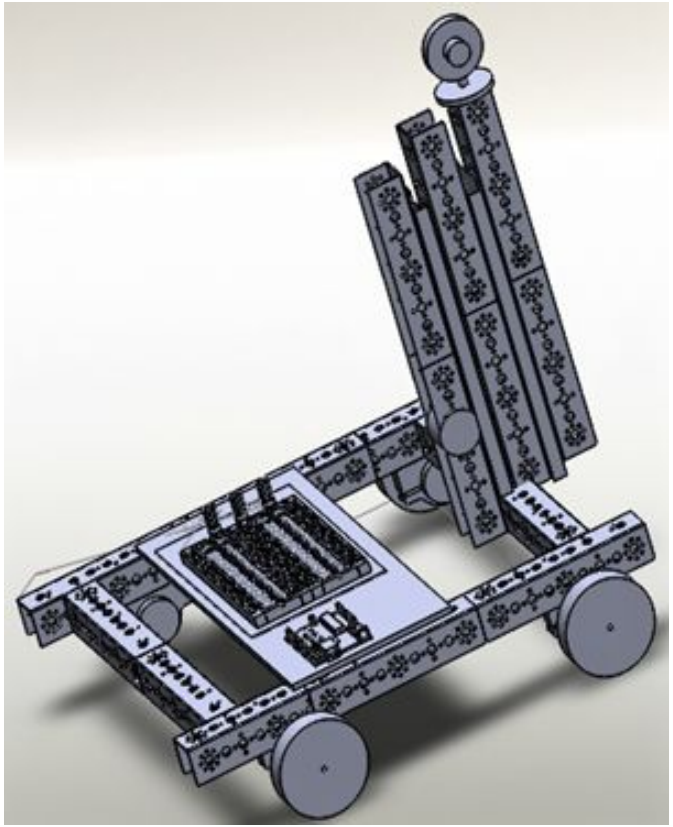


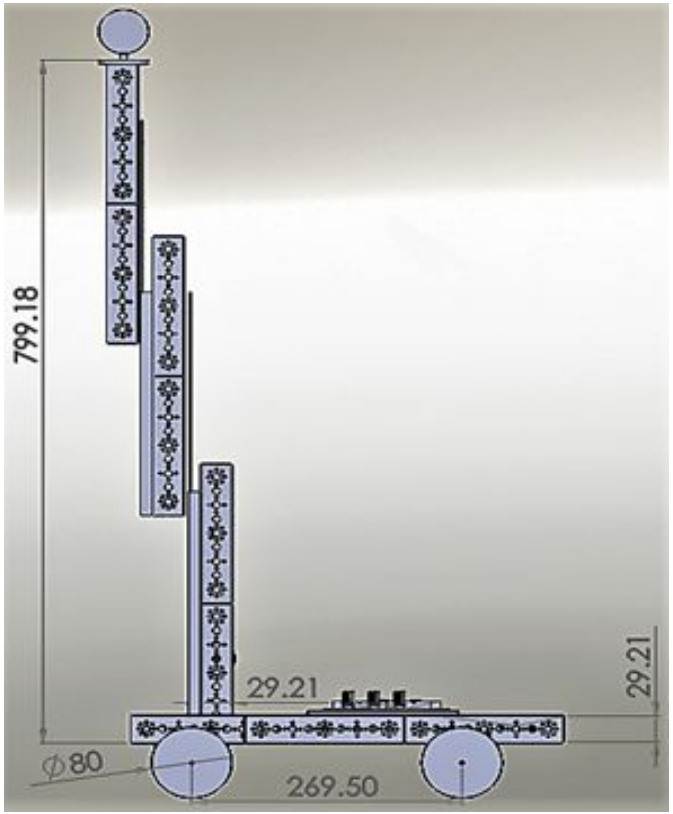
Front View



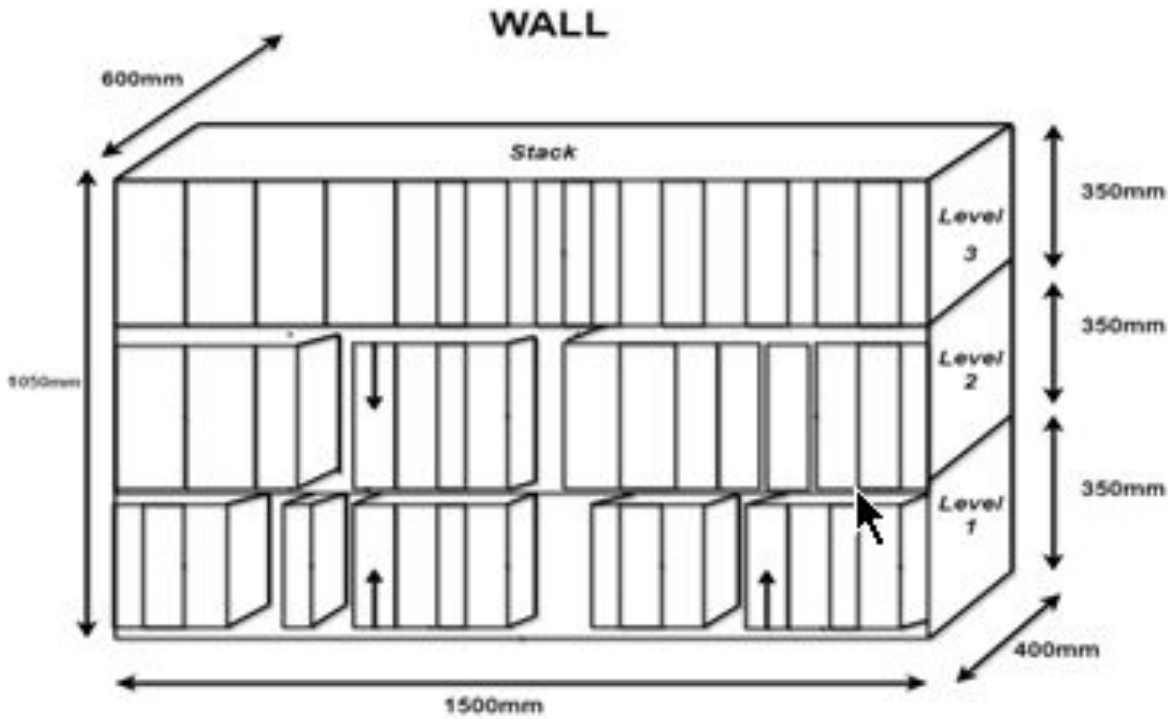
Side View

Isometric view and Full height of Bot

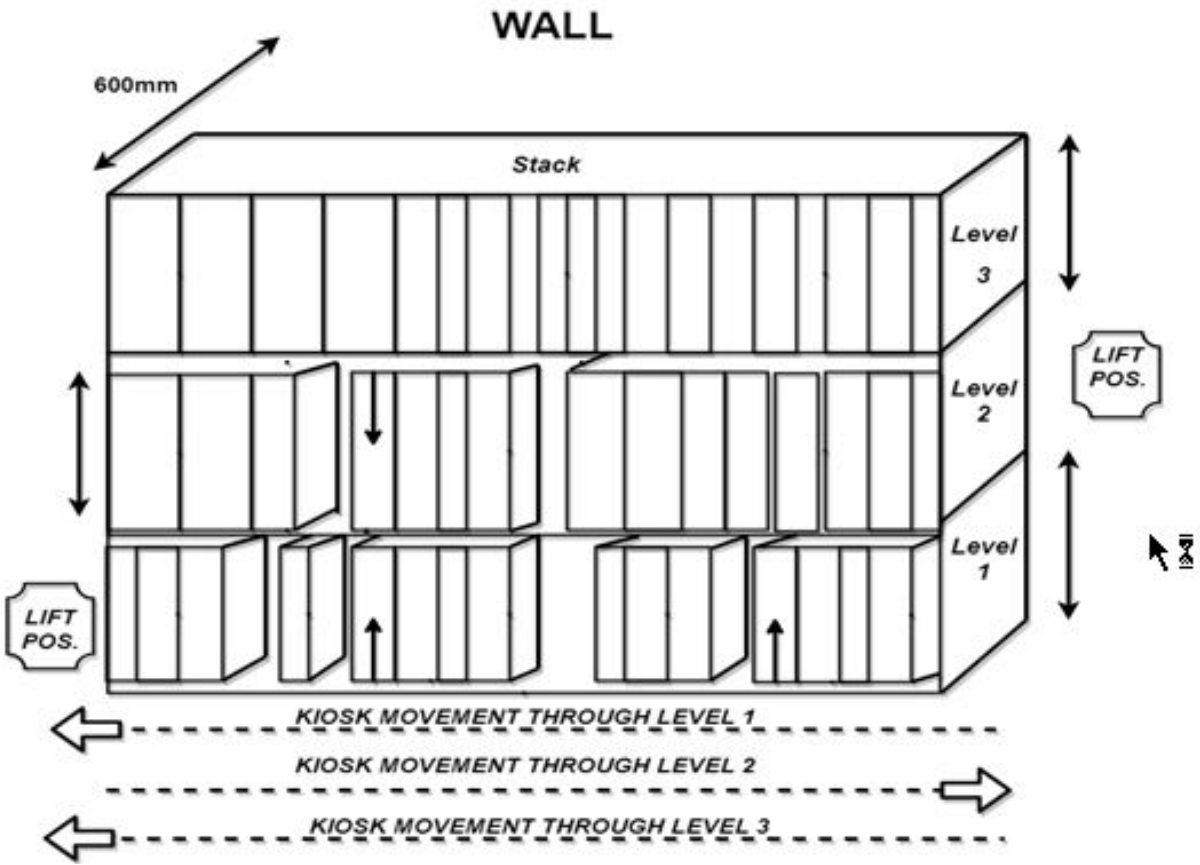




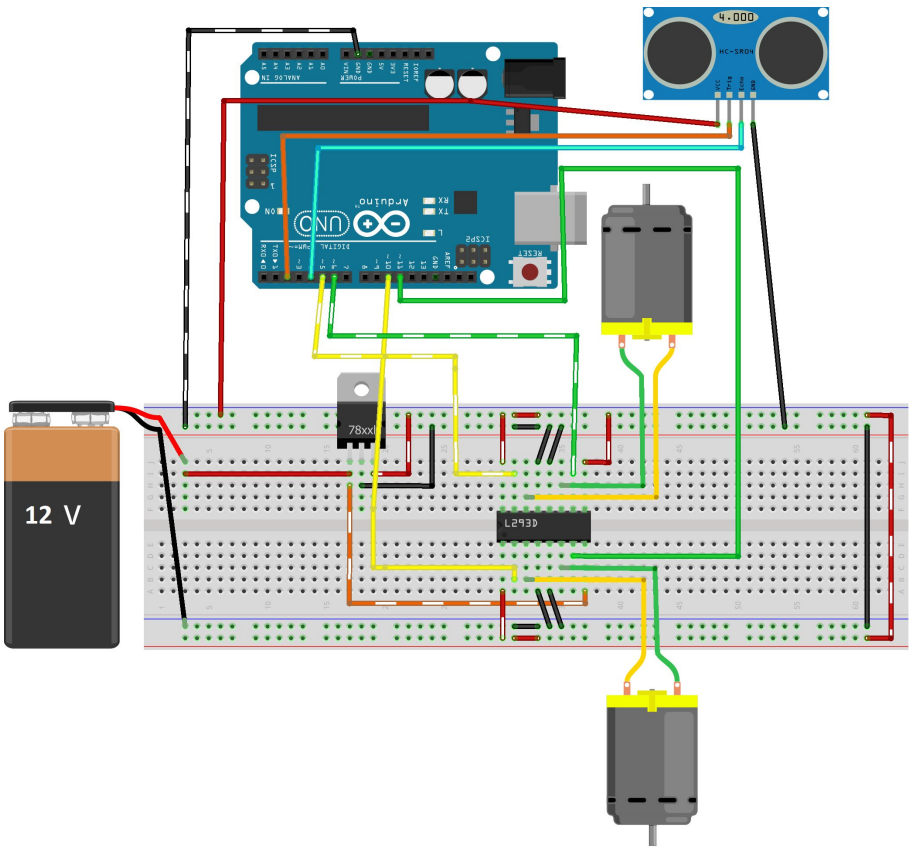
STACK MEASUREMENTS



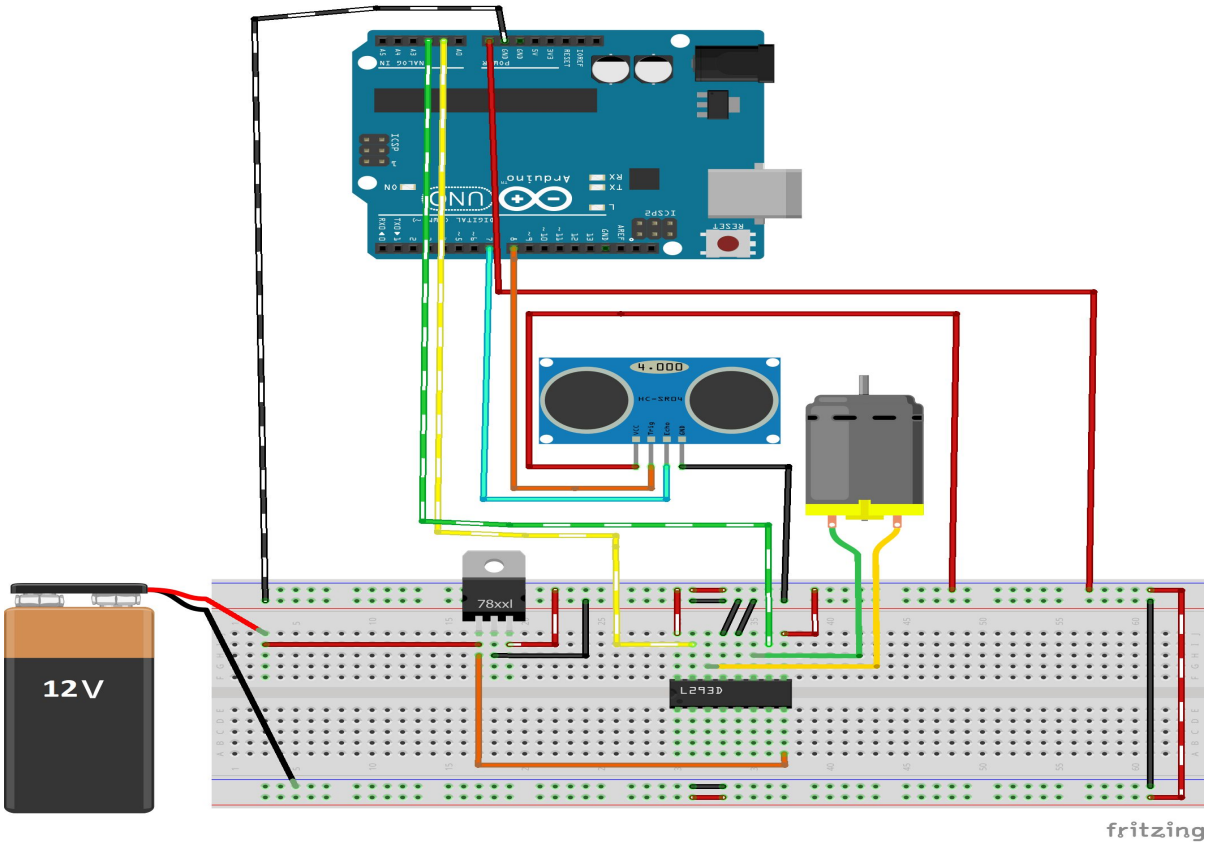
MOVEMENT ALGORITHM

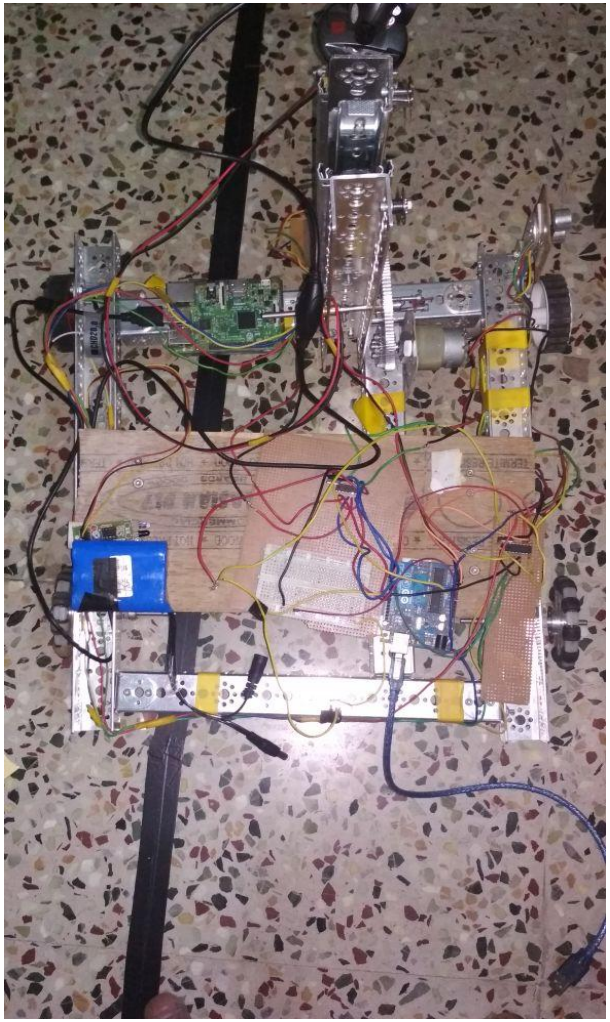


MOVEMENT CIRCUIT



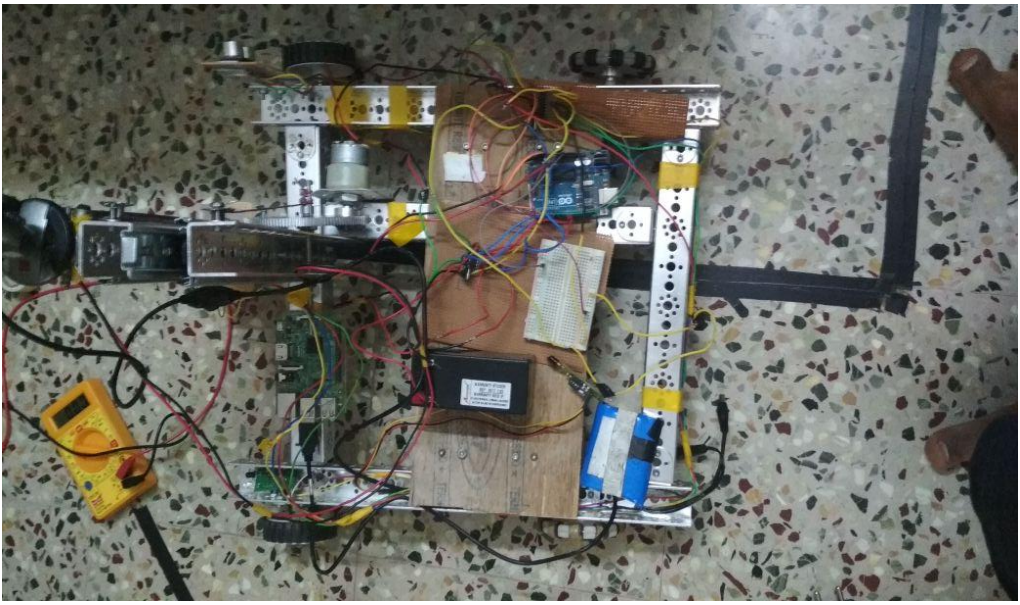
LIFT CIRCUIT

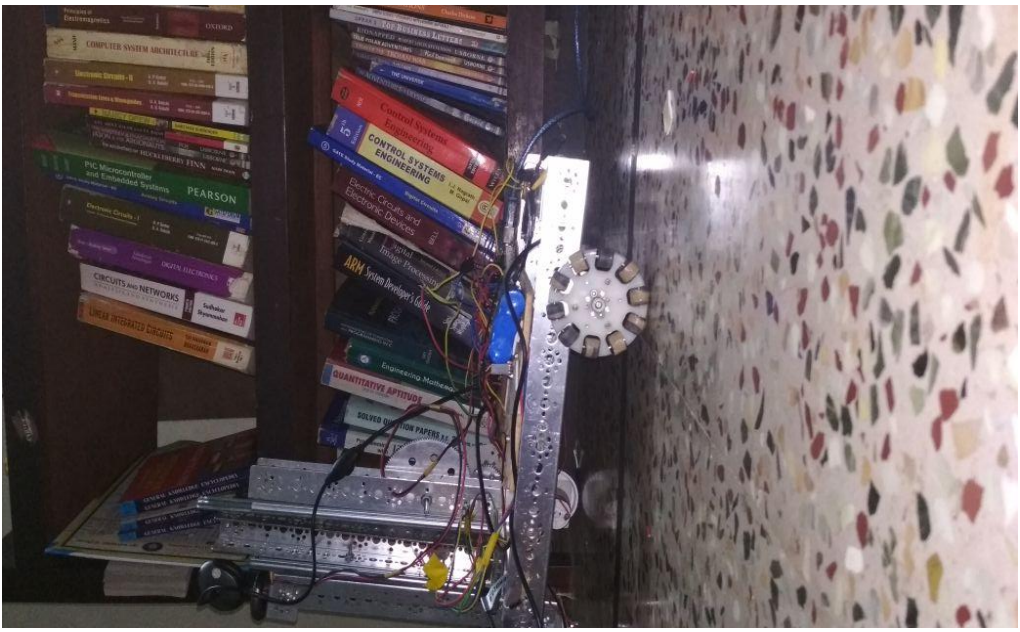


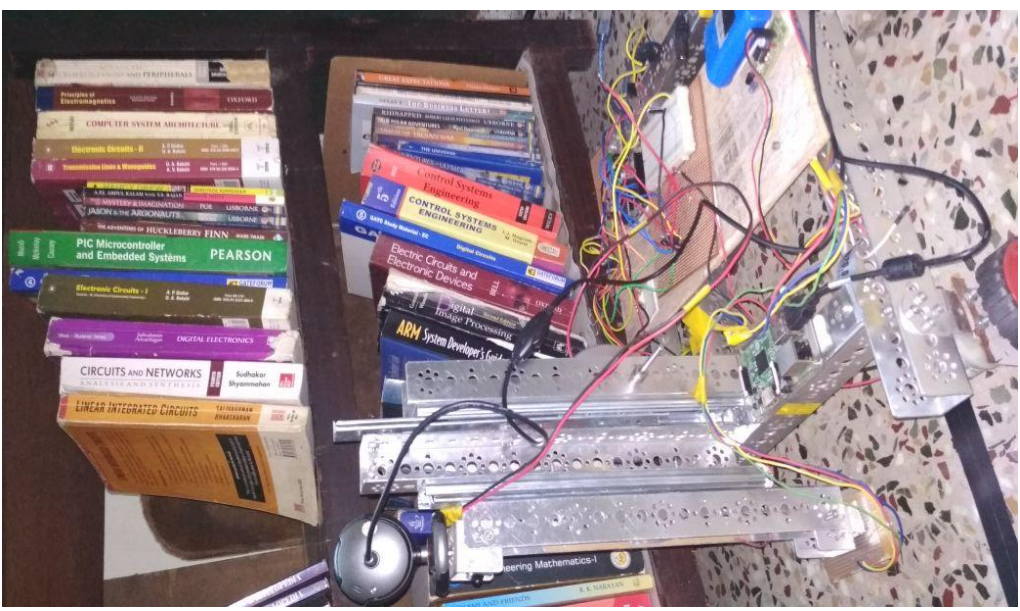



CIRCUITS
PEARSON


CIRCUITS
PEARSON




COMPUTER SYSTEM ARCHITECTURE
PIC Microcontroller and Embedded Systems
PEARSON
CIRCUITS AND NETWORKS
Sudhakar Shyammohan
LINEAR INTEGRATED CIRCUITS
Control Systems Engineering
CONTROL SYSTEMS ENGINEERING
Electric Circuits and Electronic Devices
ARM System Developer's Guide
QUANTITATIVE APTITUDE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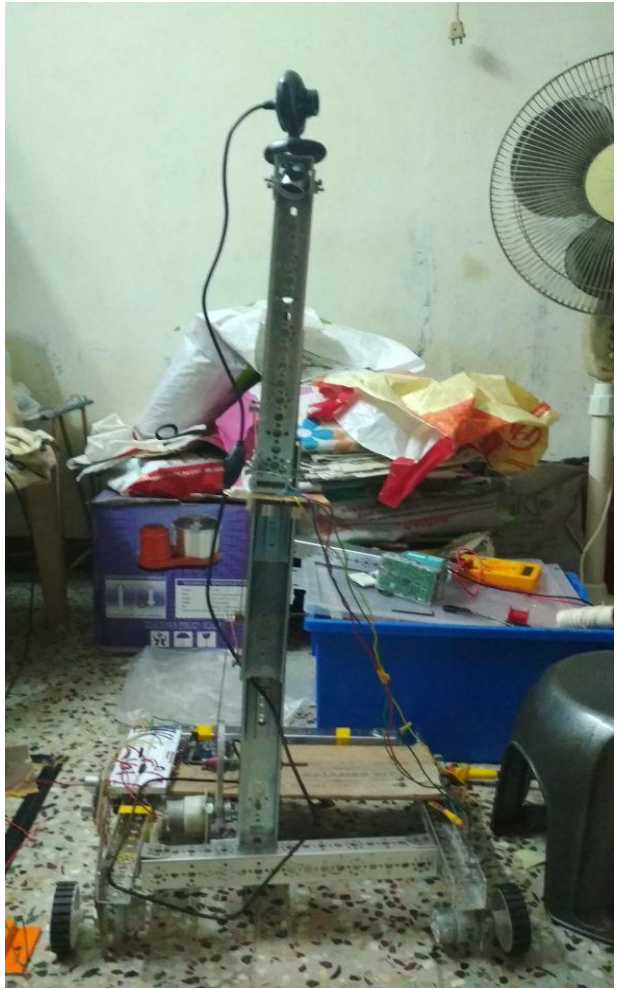
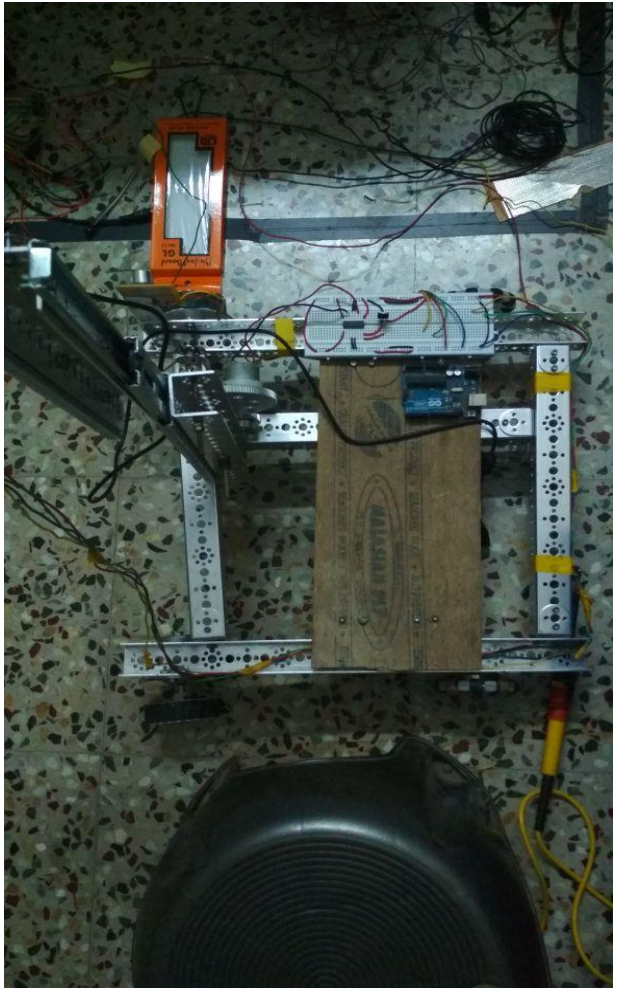
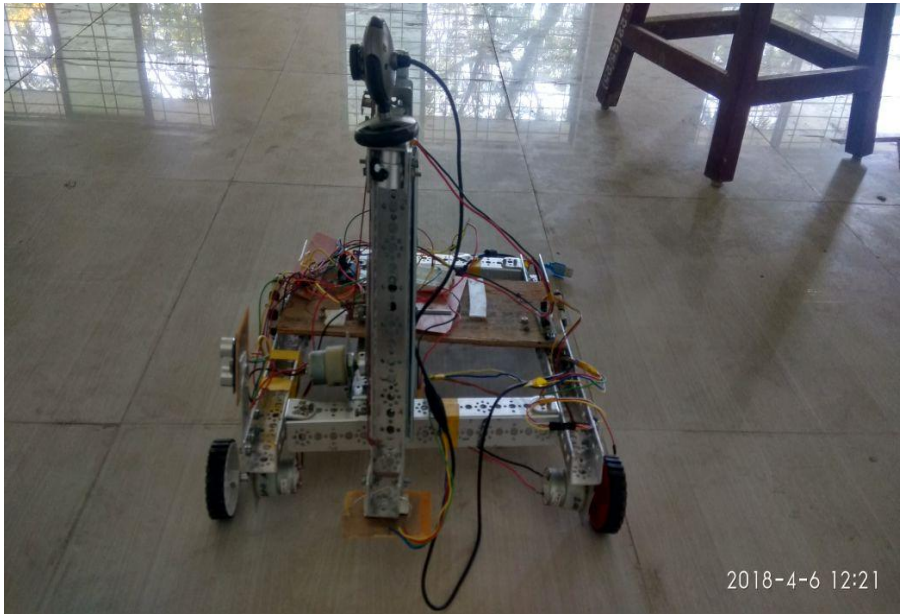
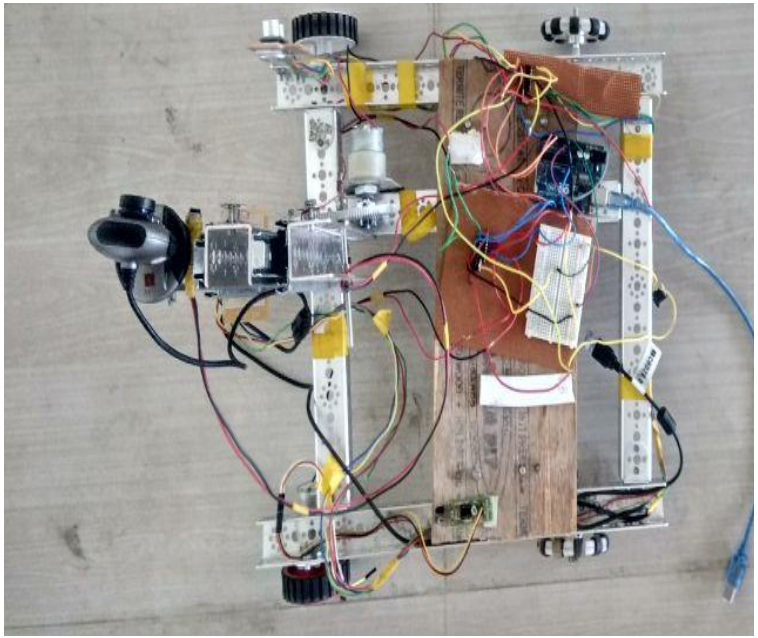




Some Images of Bot along with linear slide mechanism

FINAL DESIGN





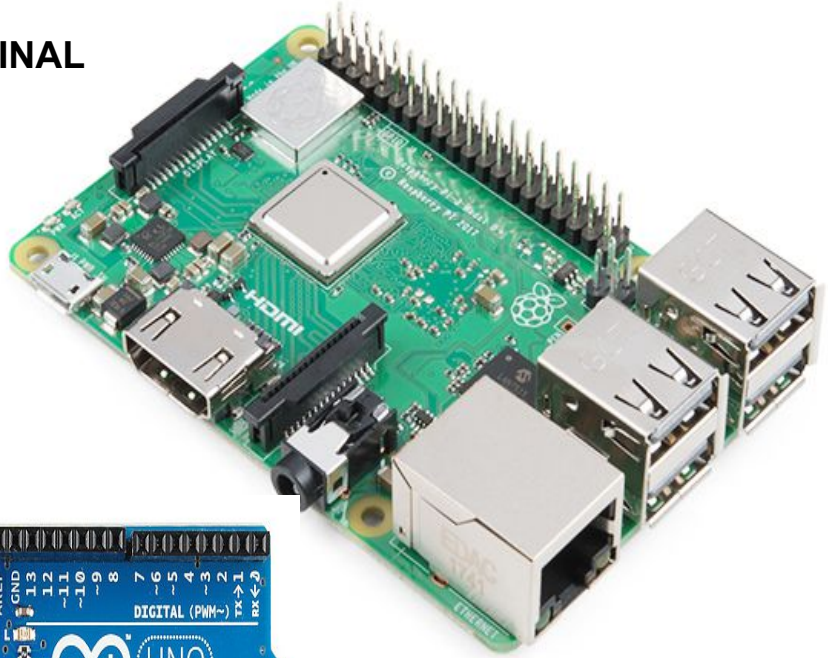
DATASET COLLECTION

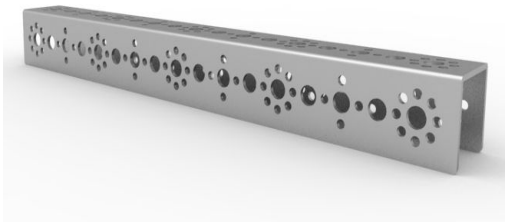
- A dataset of about 240 books from the library reference section is created.
- Dataset consists of book author name,book title and the path.

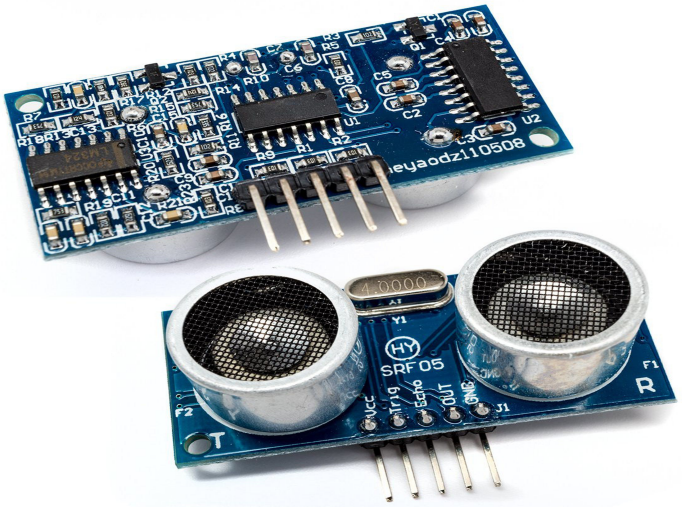
Table 1

Book Name	Author	Edition	Book Path
SOA COMPASS	BIEBERSTIN ROSE		REF4
THE PASSENGER CAR BODY	DIETER ANSELM		REF5
MULTIUSER DETECTION IN CDMA	PIERO CASTOLDI		REF6
AUTOMOTIVE VEHICLE ASSEMBLY	HERMAN TANG		REF6
RULES OF THUMB MEC ENGG	EDWARD POPE		REF6
BOUNDARY METHODS	SUBRATA MUKHERJEE		REF6
DIESEL ENGINE	BERTRAND D. HSU		REF6
USER INTERFACE DESIGN	LARRY E. WOOD		REF6
PRINCIPLES OF FUEL CELLS	XIANGUO LI		REF7
RELIABILITY CENTERED MAINTENENCE	NEIL B. BLOOM		REF9
VEHICLE ENGINE DESIGN	KEVIN L. HOAG		REF10
ENERGY TECHNOLOGY AND DIRECTIONS FOR THE FUTURE	JOHN R. FANCHI		REF11
GIGABIT ETHERNET HANDBOOK	STEPHEN SAUNDERS		REF12
THE FINITE ELEMENT METHODS FOR MECHANICS OF SOLIDS	ELLIS H. DILL		REF12
INTERNET SECURITY AND ACCELERATION SERVER 2004	STAN REIMER		REF13
NANOTECHNOLOGY	GREGORY TIMP		REF15

COMPONENTS USED (FINAL IMPLEMENTATION)






SRF05
Trig
Echo
OUT
GND
VCC


537-5488 [12V7.0AH/20HR]
Maintenance-free Sealed Lead-acid Battery
CONSTANT VOLTAGE CHARGE

EXPERIMENT RESULTS(ALGORITHMIC)

Key-point Detection Algorithm	Matched key points	False Positives	Accurate Matches	Score	True Negatives
DoG	82	13	69	84	No
	22	10	12	54	Yes
SURF	8	8	0	0	No
MSER	4	0	4	100	No
STAR	4	0	4	100	No
HARRIS	4	0	4	100	Yes
	4	4	0	0	No
DOGwith Colour descriptor	**82**	**9**	**32**	**80**	**No**

COST OF THE OVERALL PROJECT

Name	Quantity	Cost of single item	Total Cost
Raspberry Pi 3	1	3200	3200
Arduino Uno Board with USB-TTL CABLE	1	430	430
Ultrasonic Sensor SR-04F	2	120	240
Line follower Chassis	1	100	100
Iball webcam CHD 20.0	1	1350	1350
Breadboard	2	65	130
Small Breadboard	1	60	60
Lithium-Ion Battery 12V	1	1580	1580
IR sensors	5	70	350
L293D Motor Driver IC	4	55	220
Voltage Regulator LM7805	5	10	50
Dot Board	1	120	120
Motors 100 RPM	1	135	135
Motors 200 RPM	4	135	540
Line Follower Wheels	2	40	80
Omniwheels	2	150	300
Jumper Wires	40	4	160
Wires Single Strand	15 metres	5	75
Castor Wheel	1	25	25
Lead Acid battery 12V	1	450	450
Insulation Tapes	5	15	75
Double Side Tapes	4	15	60
Nylon Thread Roll	1	80	80
Bobbins	5	5	25
Allen Key Set	1	130	130

Soldering Wire	**2**	**40**	**80**
Drill Bits	**3**	**30**	**90**
Memory Card 16 GB	**1**	**430**	**430**
Quick fix	**2**	**5**	**10**
Dot Board Small	**1**	**60**	**60**
Multimeter	**1**	**230**	**230**
Metal frames - L type	**1**	**190**	**190**
Metal frames - C type	**3**	**280**	**840**
Metallic Sliders	**2**	**45**	**90**
Laser Pointer	**1**	**50**	**50**
Jumper Wires Small	**7**	**7**	**49**
Micro USB cable	**1**	**65**	**65**
Wooden board	**1**	**100**	**100**
Battery Charger	**2**	**120**	**240**
Screws ,Nuts and Bolts	**40**	**3**	**120**
Wire Cutter	**1**	**45**	**45**
Miscellaneous	**1**	**850**	**850**
Grand Total			**13504**

During Testing

MERITS AND DEMERITS (OVERALL)

MERITS:

- Only one camera is needed to detect the book instead of thousands of RFIDS tags placed in each book of the library.
- Cost efficient compared to RFID based schemes as it employs a UHF range signal for detection, the equipment cost is higher
- It is autonomous and moves only on receiving the query from user.

DEMERITS:

- Doesn't discriminate different books which have similar bindings.
- Design of kiosk may become unstable as we move heights higher than 1500mm.
- Can cause noise during lifting of camera as lot of mechanical components is involved in it.

RESULTS AND FUTURE DEVELOPMENT

- Best processing algorithm for book spine detection as it has an accuracy of 84%.
- It can able to detect book from a huge stack in minimal time i.e. detecting the requested book from a huge stack of 300 books will take time less than 5 minutes.

FUTURE WORK:

- Automatic entry to database
- Robotic arm integration[8]

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[2]. J.Thirumurugan et al.Line following robot for library inventory management system. INTERACT-2010.

[3]. K. Iwata et al.Book cover identification by using four directional features field for a small-scale library system. Proceedings of Sixth International Conference on Document Analysis and Recognition Year: 2001.

[4]. David G. Lowe, "Distinctive Image Features from Scale-Invariant Keypoints." International Journal of Computer Vision, 2004

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[5].Relja Arandjelović;Andrew Zisserman. Three things everyone should know to improve object retrieval.2012 IEEE Conference on Computer Vision and Pattern Recognition Year:2012

[6]. Mohammad Imrul Jubair; Prianka Banik, "A technique to detect books from library bookshelf image."2013 IEEE 9th International Conference on Computational Cybernetics (ICCC)

[7].Mohd.Suhaimi,Selamat,BurhanuddinYeopMajlis. Challenges in Implementing RFID Tag in a Conventional Library. IEEE International Conference on Semiconductor Electronics, Year: 2006.

[8].Stefan Heyer; Bashar Enjarini; Christos Fragkopoulos; Axel Graeser."Book Detection and Grasping in Library Scenario", ROBOTIK 2012; 7th German Conference on Robotics, Year: 2012