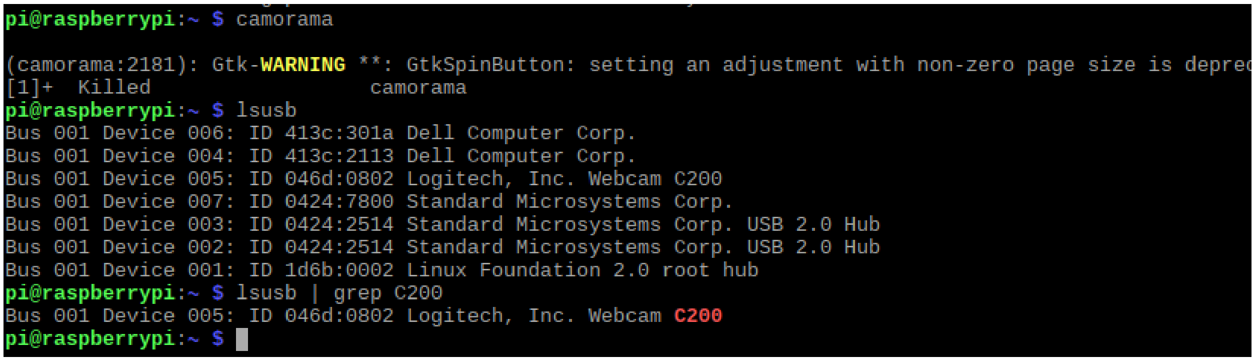
Exercise -4

Q-1

As per requirements, below are the screenshots:-

1) Logitech C200 detected and verified

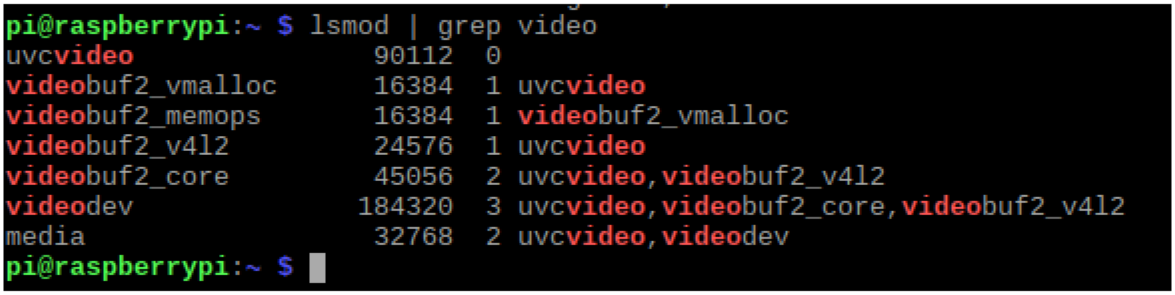


```
pi@raspberrypi:~ $ camorama

(camorama:2181): Gtk-WARNING **: GtkSpinButton: setting an adjustment with non-zero page size is deprec
[1]+  Killed                  camorama
pi@raspberrypi:~ $ lsusb
Bus 001 Device 006: ID 413c:301a Dell Computer Corp.
Bus 001 Device 004: ID 413c:2113 Dell Computer Corp.
Bus 001 Device 005: ID 046d:0802 Logitech, Inc. Webcam C200
Bus 001 Device 007: ID 0424:7800 Standard Microsystems Corp.
Bus 001 Device 003: ID 0424:2514 Standard Microsystems Corp. USB 2.0 Hub
Bus 001 Device 002: ID 0424:2514 Standard Microsystems Corp. USB 2.0 Hub
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
pi@raspberrypi:~ $ lsusb | grep C200
Bus 001 Device 005: ID 046d:0802 Logitech, Inc. Webcam C200
pi@raspberrypi:~ $ 
```

Fig :-1 Detection of camera

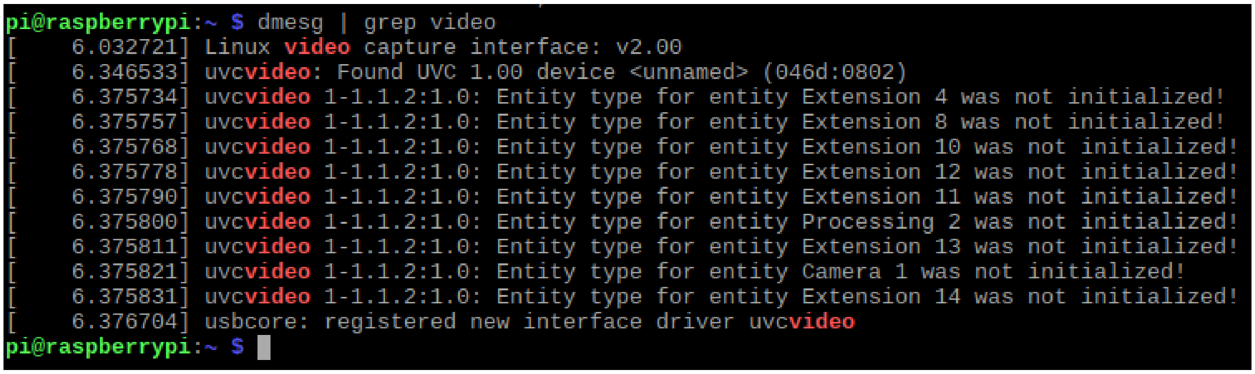
2) Use of lsmod | grep video command (lsmod shows the kernel modules which can be loaded onto the system) (grep is used to search text files for patterns) [Ref :- Wikipedia]



```
pi@raspberrypi:~ $ lsmod | grep video
uvcvideo               90112  0
videobuf2_vmalloc      16384  1 uvcvideo
videobuf2_memops       16384  1 videobuf2_vmalloc
videobuf2_v4l2         24576  1 uvcvideo
videobuf2_core         45056  2 uvcvideo,videobuf2_v4l2
videodev              184320  3 uvcvideo,videobuf2_core,videobuf2_v4l2
media                  32768  2 uvcvideo,videodev
pi@raspberrypi:~ $ 
```

Fig :-2 Use of lsmod | grep video command

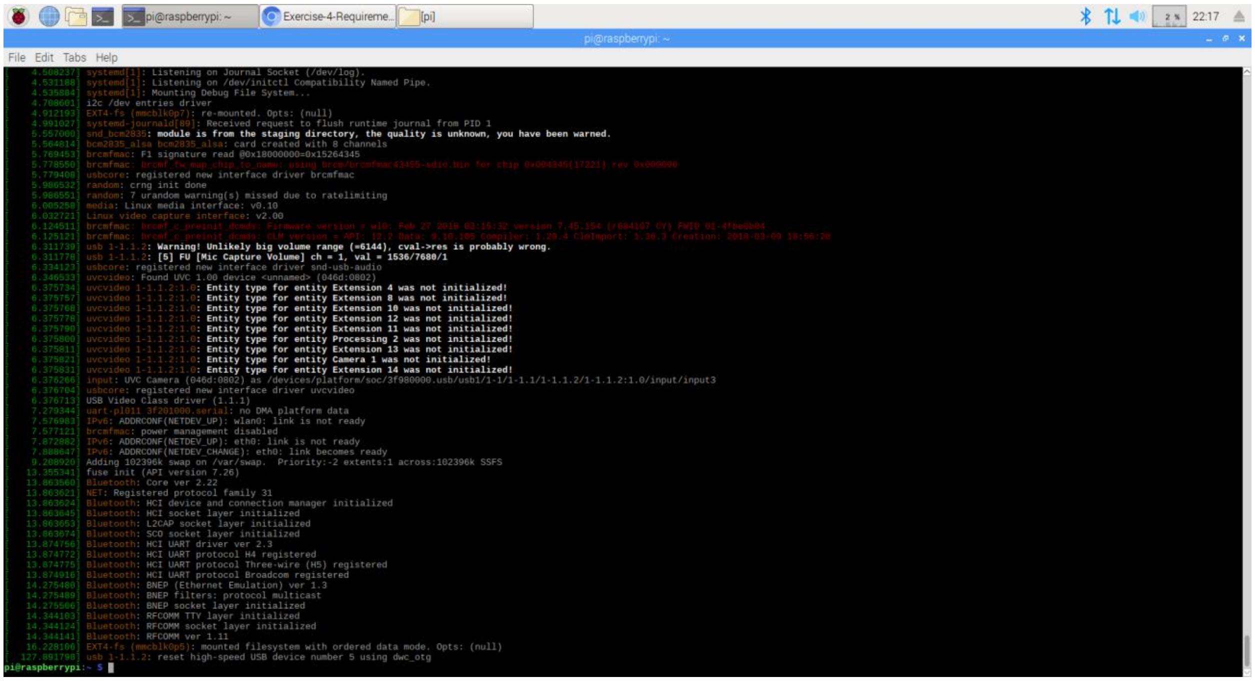
3) Use of dmesg | grep video command (dmesg used to write kernel messages in linux)[Ref :- Wikipedia]



```
pi@raspberrypi:~ $ dmesg | grep video
[    6.032721] Linux video capture interface: v2.00
[    6.346533] uvcvideo: Found UVC 1.00 device <unnamed> (046d:0802)
[    6.375734] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 4 was not initialized!
[    6.375757] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 8 was not initialized!
[    6.375768] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 10 was not initialized!
[    6.375778] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 12 was not initialized!
[    6.375790] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 11 was not initialized!
[    6.375800] uvcvideo 1-1.1.2:1.0: Entity type for entity Processing 2 was not initialized!
[    6.375811] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 13 was not initialized!
[    6.375821] uvcvideo 1-1.1.2:1.0: Entity type for entity Camera 1 was not initialized!
[    6.375831] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 14 was not initialized!
[    6.376704] usbcore: registered new interface driver uvcvideo
pi@raspberrypi:~ $ 
```

Fig:-3 Use of dmesg | grep video command (Verification of UVC driver Loaded)

4) Use of dmesg command



```
[    4.508237] systemd[1]: Listening on Journal Socket (/dev/log).
[    4.531188] systemd[1]: Listening on /dev/initctl Compatibility Named Pipe.
[    4.535884] systemd[1]: Mounting Debug File System...
[    4.708601] i2c /dev entries driver
[    4.912193] EXT4-fs (mmcblk0p7): re-mounted. Opts: (null)
[    4.991027] systemd-journald[89]: Received request to flush runtime journal from PID 1
[    5.557000] snd_bcm2835: module is from the staging directory, the quality is unknown, you have been warned.
[    5.564814] bcm2835_alsa bcm2835_alsa: card created with 8 channels
[    5.769453] brcmfmac: F1 signature read @0x18000000=0x15264345
[    5.778550] brcmfmac: brcmf_fw_map_chip_to_name: using brcm/brcmfmac43455-sdio.bin for chip 0x004345(17221) rev 0x000006
[    5.779408] usbcore: registered new interface driver brcmfmac
[    5.986532] random: crng init done
[    5.986551] random: 7 urandom warning(s) missed due to ratelimiting
[    6.005258] media: Linux media interface: v0.10
[    6.032721] Linux video capture interface: v2.00
[    6.124511] brcmfmac: brcmf_c_preinit_dcmds: Firmware version = wl0: Feb 27 2018 03:15:32 version 7.45.154 (r684107 CY) FWID 01-4fbe0b04
[    6.125121] brcmfmac: brcmf_c_preinit_dcmds: CLM version = API: 12.2 Data: 9.10.105 Compiler: 1.29.4 ClmImport: 1.36.3 Creation: 2018-03-09 18:56:28
[    6.311739] usb 1-1.1.2: Warning! Unlikely big volume range (=6144), cval->res is probably wrong.
[    6.311778] usb 1-1.1.2: [5] FU [Mic Capture Volume] ch = 1, val = 1536/7680/1
[    6.334123] usbcore: registered new interface driver snd-usb-audio
[    6.346533] uvcvideo: Found UVC 1.00 device <unnamed> (046d:0802)
[    6.375734] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 4 was not initialized!
[    6.375757] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 8 was not initialized!
[    6.375768] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 10 was not initialized!
[    6.375778] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 12 was not initialized!
[    6.375790] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 11 was not initialized!
[    6.375800] uvcvideo 1-1.1.2:1.0: Entity type for entity Processing 2 was not initialized!
[    6.375811] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 13 was not initialized!
[    6.375821] uvcvideo 1-1.1.2:1.0: Entity type for entity Camera 1 was not initialized!
[    6.375831] uvcvideo 1-1.1.2:1.0: Entity type for entity Extension 14 was not initialized!
[    6.376266] input: UVC Camera (046d:0802) as /devices/platform/soc/3f980000.usb/usb1/1-1/1-1.1/1-1.1.2/1-1.1.2:1.0/input/input3
[    6.376704] usbcore: registered new interface driver uvcvideo
[    6.376713] USB Video Class driver (1.1.1)
[    7.279344] uart-pl011 3f201000.serial: no DMA platform data
[    7.576983] IPv6: ADDRCONF(NETDEV_UP): wlan0: link is not ready
[    7.577121] brcmfmac: power management disabled
[    7.872882] IPv6: ADDRCONF(NETDEV_UP): eth0: link is not ready
[    7.888647] IPv6: ADDRCONF(NETDEV_CHANGE): eth0: link becomes ready
[    9.208920] Adding 102396k swap on /var/swap.  Priority:-2 extents:1 across:102396k SSFS
[   13.355341] fuse init (API version 7.26)
[   13.863560] Bluetooth: Core ver 2.22
[   13.863621] NET: Registered protocol family 31
[   13.863624] Bluetooth: HCI device and connection manager initialized
[   13.863645] Bluetooth: HCI socket layer initialized
[   13.863653] Bluetooth: L2CAP socket layer initialized
[   13.863674] Bluetooth: SCO socket layer initialized
[   13.874756] Bluetooth: HCI UART driver ver 2.3
[   13.874772] Bluetooth: HCI UART protocol H4 registered
[   13.874775] Bluetooth: HCI UART protocol Three-wire (H5) registered
[   13.874916] Bluetooth: HCI UART protocol Broadcom registered
[   14.275480] Bluetooth: BNEP (Ethernet Emulation) ver 1.3
[   14.275489] Bluetooth: BNEP filters: protocol multicast
[   14.275506] Bluetooth: BNEP socket layer initialized
[   14.344103] Bluetooth: RFCOMM TTY layer initialized
[   14.344124] Bluetooth: RFCOMM socket layer initialized
[   14.344141] Bluetooth: RFCOMM ver 1.11
[   16.228106] EXT4-fs (mmcblk0p5): mounted filesystem with ordered data mode. Opts: (null)
[  127.891798] usb 1-1.1.2: reset high-speed USB device number 5 using dwc_otg
pi@raspberrypi:~ $ 
```

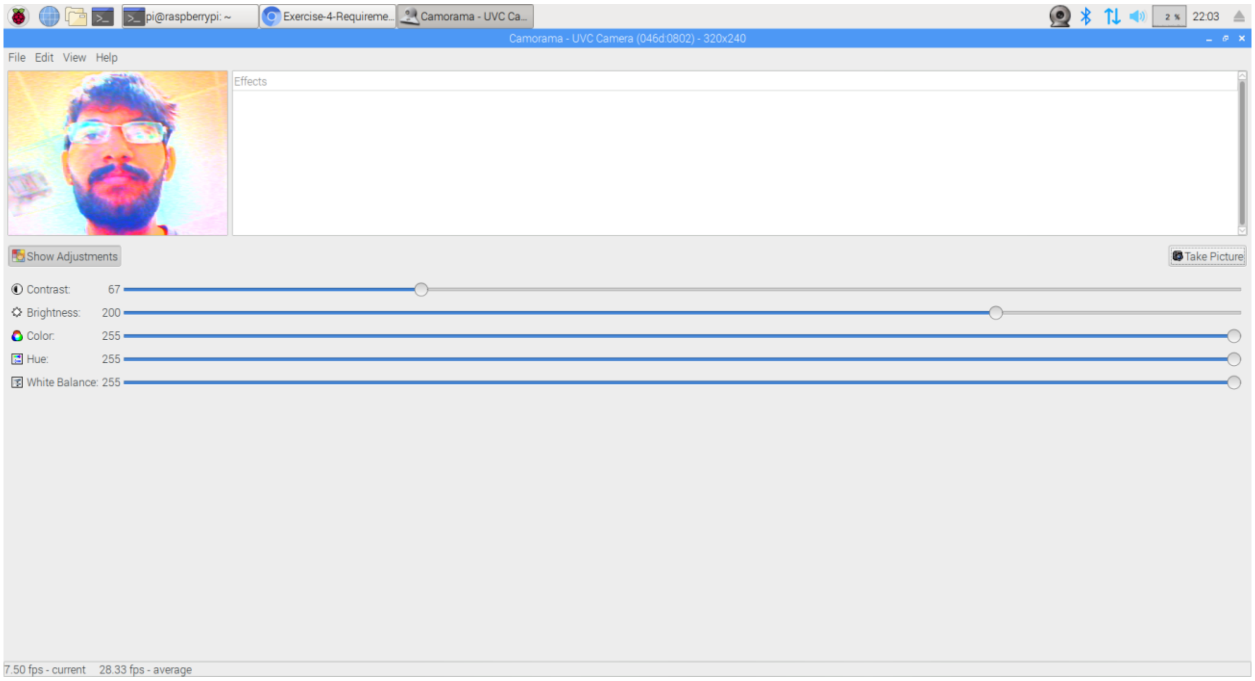
Fig:-4 Use of dmesg command

Camorama is used to take images using webcam (here logitech C200).
I installed it using the command

apt-get install camorama.

Here, as shown in the figure :-
We can take pictures and then also change the effects like contrast, brightness, colour,Hue, White balance upto 255 units.

Example of my face capture is shown with different effects.



Contrast: 67
Brightness: 200
Color: 255
Hue: 255
White Balance: 255

7.50 fps - current   28.33 fps - average

Fig:- 5 Use of Tool (camorama) by different effects and verification

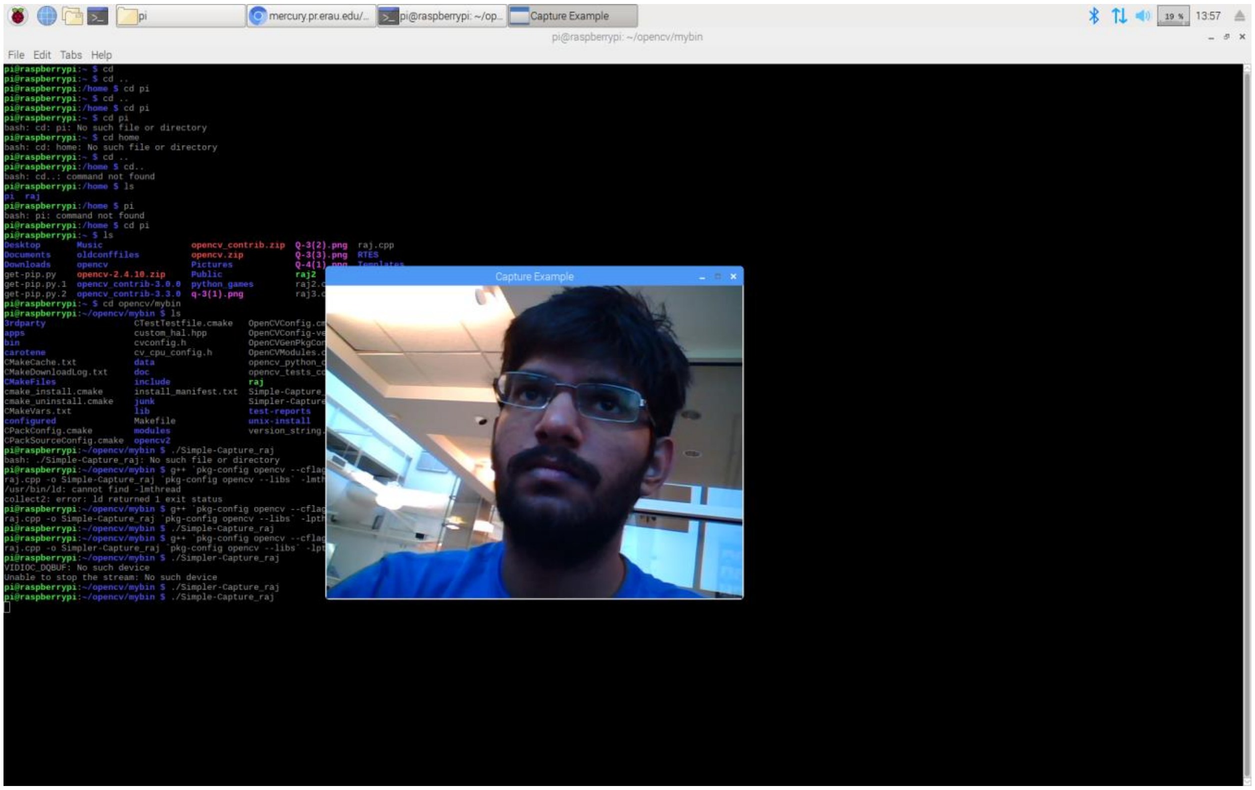
Q-3

In R-pi 3 B+, I installed opencv 3 using this link.., since it is not pre-installed like Jetson. https://www.pyimagesearch.com/2015/10/26/how-to-install-opencv-3-on-raspbian-jessie/

After Installing opencv3, I ran demo codes given by Professor Sam Siewert

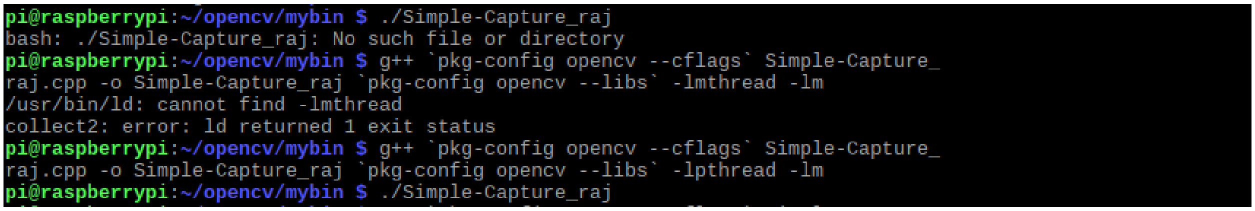
Below are the screenshots of Simple Capture

1) **Simple Capture**



```
pi@raspberrypi:~ $ cd
pi@raspberrypi:~ $ cd ..
pi@raspberrypi:/home $ cd pi
pi@raspberrypi:~ $ cd ..
pi@raspberrypi:/home $ cd pi
pi@raspberrypi:~ $ cd pi
bash: cd: pi: No such file or directory
pi@raspberrypi:~ $ cd home
bash: cd: home: No such file or directory
pi@raspberrypi:~ $ cd ..
pi@raspberrypi:/home $ cd..
bash: cd..: command not found
pi@raspberrypi:/home $ ls
pi  raj
pi@raspberrypi:/home $ pi
bash: pi: command not found
pi@raspberrypi:/home $ cd pi
pi@raspberrypi:~ $ ls
Desktop      Music                 opencv_contrib.zip  Q-3(2).png  raj.cpp
Documents    oldconffiles          opencv.zip          Q-3(3).png  RTES
Downloads    opencv                Pictures            Q-4(1).png  Templates
get-pip.py   opencv-2.4.10.zip     Public              raj2
get-pip.py.1 opencv_contrib-3.0.0  python_games        raj2.c
get-pip.py.2 opencv_contrib-3.3.0  q-3(1).png          raj3.c
pi@raspberrypi:~ $ cd opencv/mybin
pi@raspberrypi:~/opencv/mybin $ ls
3rdparty                  CTestTestfile.cmake   OpenCVConfig.cm
apps                      custom_hal.hpp        OpenCVConfig-ve
bin                       cvconfig.h            OpenCVGenPkgCon
carotene                  cv_cpu_config.h       OpenCVModules.c
CMakeCache.txt            data                  opencv_python_c
CMakeDownloadLog.txt      doc                   opencv_tests_co
CMakeFiles                include               raj
cmake_install.cmake       install_manifest.txt  Simple-Capture_
cmake_uninstall.cmake     junk                  Simpler-Capture
CMakeVars.txt             lib                   test-reports
configured                Makefile              unix-install
CPackConfig.cmake         modules               version_string.
CPackSourceConfig.cmake   opencv2
pi@raspberrypi:~/opencv/mybin $ ./Simple-Capture_raj
bash: ./Simple-Capture_raj: No such file or directory
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflag
raj.cpp -o Simple-Capture_raj `pkg-config opencv --libs` -lmth
/usr/bin/ld: cannot find -lmthread
collect2: error: ld returned 1 exit status
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflag
raj.cpp -o Simple-Capture_raj `pkg-config opencv --libs` -lpth
pi@raspberrypi:~/opencv/mybin $ ./Simple-Capture_raj
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflag
raj.cpp -o Simpler-Capture_raj `pkg-config opencv --libs` -lpt
pi@raspberrypi:~/opencv/mybin $ ./Simpler-Capture_raj
VIDIOC_DQBUF: No such device
Unable to stop the stream: No such device
pi@raspberrypi:~/opencv/mybin $ ./Simpler-Capture_raj
pi@raspberrypi:~/opencv/mybin $ ./Simple-Capture_raj
```

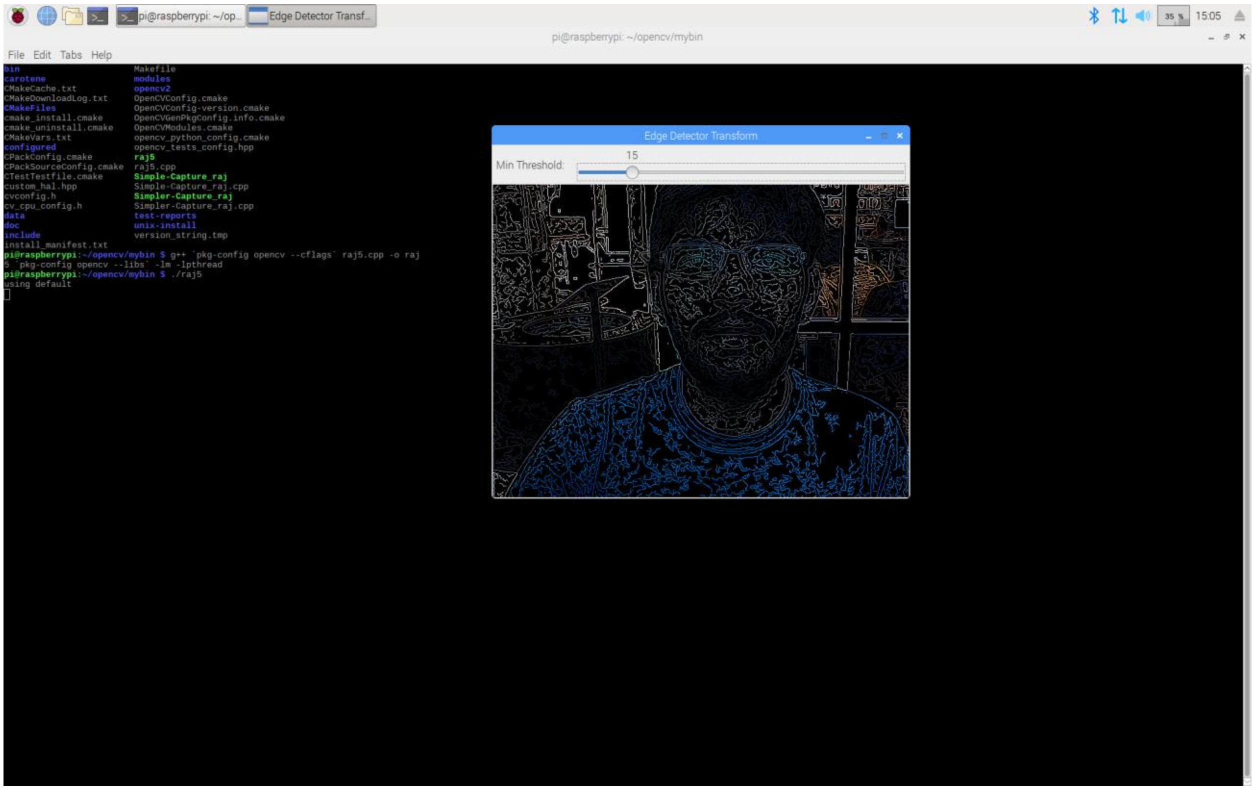
Fig:-6 Output of Simple Capture



```
pi@raspberrypi:~/opencv/mybin $ ./Simple-Capture_raj
bash: ./Simple-Capture_raj: No such file or directory
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflags` Simple-Capture_
raj.cpp -o Simple-Capture_raj `pkg-config opencv --libs` -lmthread -lm
/usr/bin/ld: cannot find -lmthread
collect2: error: ld returned 1 exit status
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflags` Simple-Capture_
raj.cpp -o Simple-Capture_raj `pkg-config opencv --libs` -lpthread -lm
pi@raspberrypi:~/opencv/mybin $ ./Simple-Capture_raj
```

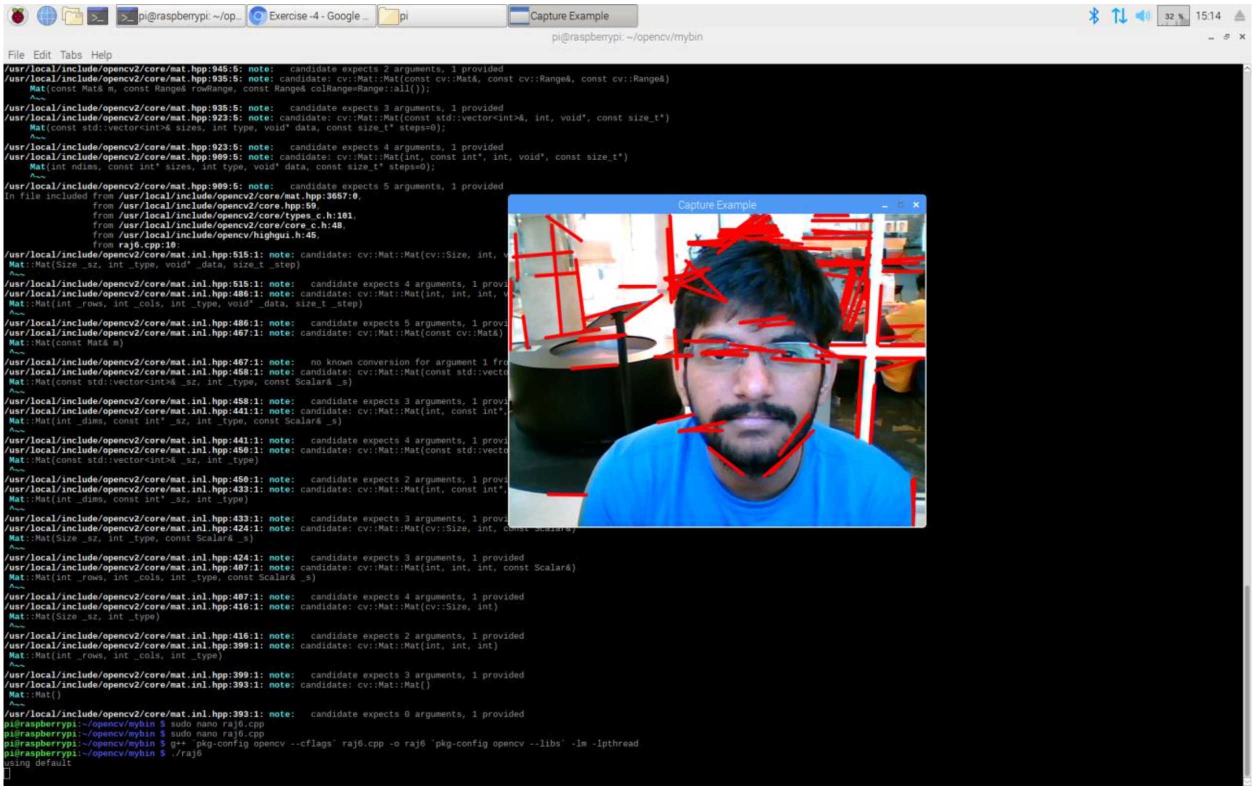
Fig:- 7 Verification and Code compilation of opencv and Simple Capture Code by Professor Sam Siewert

Q-4



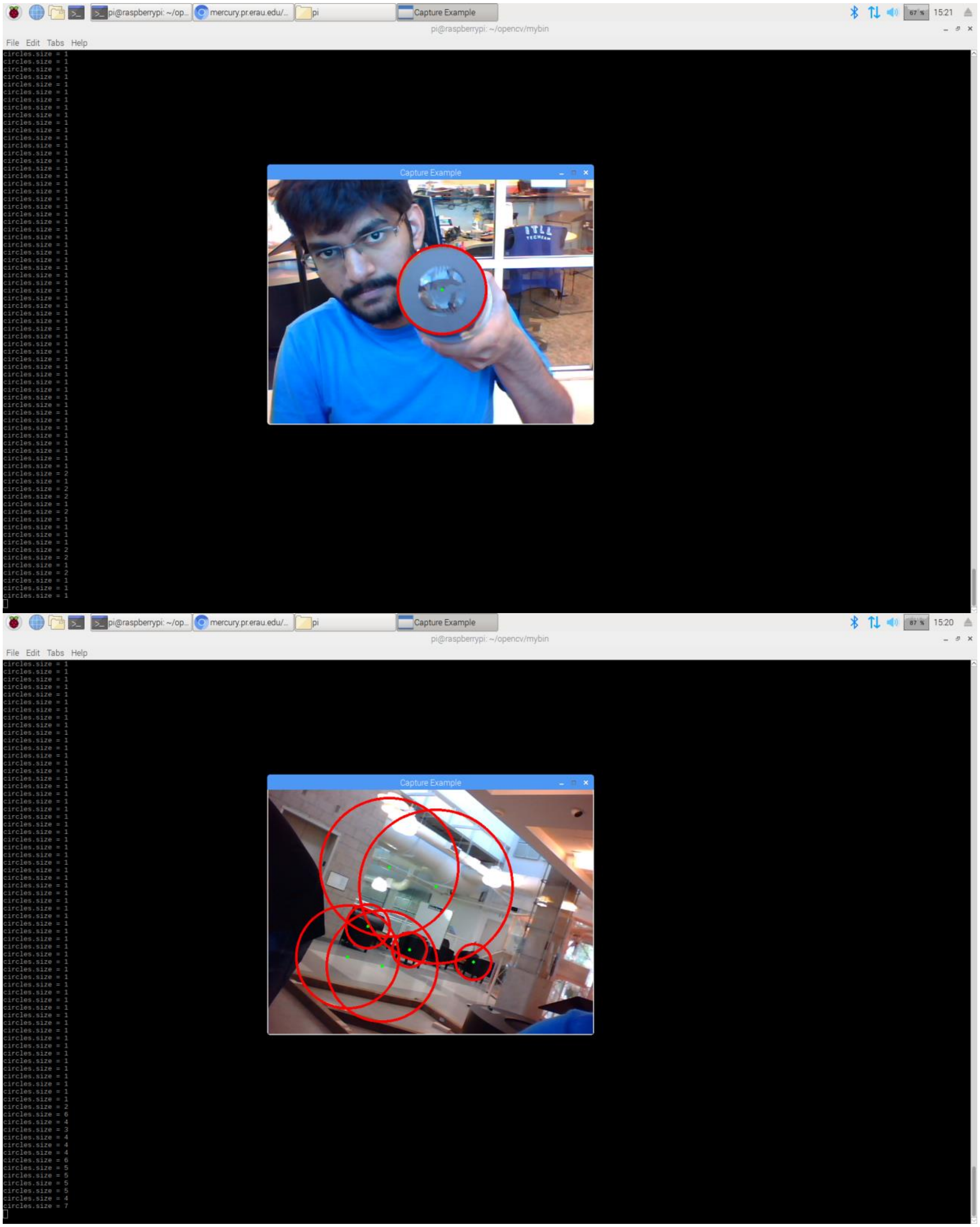
```
bin                       Makefile
carotene                  modules
CMakeCache.txt            opencv2
CMakeDownloadLog.txt      OpenCVConfig.cmake
CMakeFiles                OpenCVConfig-version.cmake
cmake_install.cmake       OpenCVGenPkgConfig.info.cmake
cmake_uninstall.cmake     OpenCVModules.cmake
CMakeVars.txt             opencv_python_config.cmake
configured                opencv_tests_config.hpp
CPackConfig.cmake         raj5
CPackSourceConfig.cmake   raj5.cpp
CTestTestfile.cmake       Simple-Capture_raj
custom_hal.hpp            Simple-Capture_raj.cpp
cvconfig.h                Simpler-Capture_raj
cv_cpu_config.h           Simpler-Capture_raj.cpp
data                      test-reports
doc                       unix-install
include                   version_string.tmp
install_manifest.txt
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflags` raj5.cpp -o raj
5 `pkg-config opencv --libs` -lm -lpthread
pi@raspberrypi:~/opencv/mybin $ ./raj5
using default
```

Fig :-8 Output of Canny interactive



```
/usr/local/include/opencv2/core/mat.hpp:945:5: note:   candidate expects 2 arguments, 1 provided
/usr/local/include/opencv2/core/mat.hpp:935:5: note: candidate: cv::Mat::Mat(const cv::Mat&, const cv::Range&, const cv::Range&)
     Mat(const Mat& m, const Range& rowRange, const Range& colRange=Range::all());
     ^~~
/usr/local/include/opencv2/core/mat.hpp:935:5: note:   candidate expects 3 arguments, 1 provided
/usr/local/include/opencv2/core/mat.hpp:923:5: note: candidate: cv::Mat::Mat(const std::vector<int>&, int, void*, const size_t*)
     Mat(const std::vector<int>& sizes, int type, void* data, const size_t* steps=0);
     ^~~
/usr/local/include/opencv2/core/mat.hpp:923:5: note:   candidate expects 4 arguments, 1 provided
/usr/local/include/opencv2/core/mat.hpp:909:5: note: candidate: cv::Mat::Mat(int, const int*, int, void*, const size_t*)
     Mat(int ndims, const int* sizes, int type, void* data, const size_t* steps=0);
     ^~~
/usr/local/include/opencv2/core/mat.hpp:909:5: note:   candidate expects 5 arguments, 1 provided
In file included from /usr/local/include/opencv2/core/mat.hpp:3657:0,
                 from /usr/local/include/opencv2/core.hpp:59,
                 from /usr/local/include/opencv2/core/types_c.h:101,
                 from /usr/local/include/opencv2/core/core_c.h:48,
                 from /usr/local/include/opencv/highgui.h:45,
                 from raj6.cpp:10:
/usr/local/include/opencv2/core/mat.inl.hpp:515:1: note: candidate: cv::Mat::Mat(cv::Size, int, v
 Mat::Mat(Size _sz, int _type, void* _data, size_t _step)
 ^~~
/usr/local/include/opencv2/core/mat.inl.hpp:515:1: note:   candidate expects 4 arguments, 1 provi
/usr/local/include/opencv2/core/mat.inl.hpp:486:1: note: candidate: cv::Mat::Mat(int, int, int, v
 Mat::Mat(int _rows, int _cols, int _type, void* _data, size_t _step)
 ^~~
/usr/local/include/opencv2/core/mat.inl.hpp:486:1: note:   candidate expects 5 arguments, 1 provi
/usr/local/include/opencv2/core/mat.inl.hpp:467:1: note: candidate: cv::Mat::Mat(const cv::Mat&)
 Mat::Mat(const Mat& m)
 ^~~
/usr/local/include/opencv2/core/mat.inl.hpp:467:1: note:   no known conversion for argument 1 fro
/usr/local/include/opencv2/core/mat.inl.hpp:458:1: note: candidate: cv::Mat::Mat(const std::vecto
 Mat::Mat(const std::vector<int>& _sz, int _type, const Scalar& _s)
 ^~~
/usr/local/include/opencv2/core/mat.inl.hpp:458:1: note:   candidate expects 3 arguments, 1 provi
/usr/local/include/opencv2/core/mat.inl.hpp:441:1: note: candidate: cv::Mat::Mat(int, const int*,
 Mat::Mat(int _dims, const int* _sz, int _type, const Scalar& _s)
 ^~~
/usr/local/include/opencv2/core/mat.inl.hpp:441:1: note:   candidate expects 4 arguments, 1 provi
/usr/local/include/opencv2/core/mat.inl.hpp:450:1: note: candidate: cv::Mat::Mat(const std::vecto
 Mat::Mat(const std::vector<int>& _sz, int _type)
 ^~~
/usr/local/include/opencv2/core/mat.inl.hpp:450:1: note:   candidate expects 2 arguments, 1 provi
/usr/local/include/opencv2/core/mat.inl.hpp:433:1: note: candidate: cv::Mat::Mat(int, const int*,
 Mat::Mat(int _dims, const int* _sz, int _type)
 ^~~
/usr/local/include/opencv2/core/mat.inl.hpp:433:1: note:   candidate expects 3 arguments, 1 provi
/usr/local/include/opencv2/core/mat.inl.hpp:424:1: note: candidate: cv::Mat::Mat(cv::Size, int, const Scalar&)
 Mat::Mat(Size _sz, int _type, const Scalar& _s)
 ^~~
/usr/local/include/opencv2/core/mat.inl.hpp:424:1: note:   candidate expects 3 arguments, 1 provided
/usr/local/include/opencv2/core/mat.inl.hpp:407:1: note: candidate: cv::Mat::Mat(int, int, int, const Scalar&)
 Mat::Mat(int _rows, int _cols, int _type, const Scalar& _s)
 ^~~
/usr/local/include/opencv2/core/mat.inl.hpp:407:1: note:   candidate expects 4 arguments, 1 provided
/usr/local/include/opencv2/core/mat.inl.hpp:416:1: note: candidate: cv::Mat::Mat(cv::Size, int)
 Mat::Mat(Size _sz, int _type)
 ^~~
/usr/local/include/opencv2/core/mat.inl.hpp:416:1: note:   candidate expects 2 arguments, 1 provided
/usr/local/include/opencv2/core/mat.inl.hpp:399:1: note: candidate: cv::Mat::Mat(int, int, int)
 Mat::Mat(int _rows, int _cols, int _type)
 ^~~
/usr/local/include/opencv2/core/mat.inl.hpp:399:1: note:   candidate expects 3 arguments, 1 provided
/usr/local/include/opencv2/core/mat.inl.hpp:393:1: note: candidate: cv::Mat::Mat()
 Mat::Mat()
 ^~~
/usr/local/include/opencv2/core/mat.inl.hpp:393:1: note:   candidate expects 0 arguments, 1 provided
pi@raspberrypi:~/opencv/mybin $ sudo nano raj6.cpp
pi@raspberrypi:~/opencv/mybin $ sudo nano raj6.cpp
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflags` raj6.cpp -o raj6 `pkg-config opencv --libs` -lm -lpthread
pi@raspberrypi:~/opencv/mybin $ ./raj6
using default
```

Fig:-9 Output of Hough - interactive



```
circles.size = 1
circles.size = 1
circles.size = 1
circles.size = 1
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circles.size = 1
circles.size = 1
circles.size = 1
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circles.size = 2
circles.size = 1
circles.size = 2
circles.size = 2
circles.size = 1
circles.size = 2
circles.size = 1
circles.size = 1
circles.size = 1
circles.size = 1
circles.size = 2
circles.size = 2
circles.size = 1
circles.size = 2
circles.size = 1
circles.size = 1
circles.size = 1
```

```
circles.size = 1
circles.size = 1
circles.size = 1
circles.size = 1
circles.size = 1
circles.size = 1
circles.size = 1
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circles.size = 1
circles.size = 1
circles.size = 1
circles.size = 1
circles.size = 2
circles.size = 6
circles.size = 4
circles.size = 3
circles.size = 4
circles.size = 4
circles.size = 4
circles.size = 6
circles.size = 5
circles.size = 5
circles.size = 5
circles.size = 5
circles.size = 4
circles.size = 7
```

Fig :- 10 output of Hough -elliptical Interactive

Explanation of code of canny-Interactive :-

1) **To run this code , I edited the code by adding one library i.e. #include <opencv/highgui.h>**
2) **I am running this code on 640*480 resolution.**

Canny-Edge Detector :- The canny edge detector is an edge detection operator that uses a multi stage algorithm to detect a wide range of edges in images. [2] It is very useful in computer vision , it extracts useful information from the image , removes extra stuff which is not required from the background and then uses structural information from different vision objects.

There are 3 general criteria for edge detection :- [2]

1) Detection with low error rate (as many images as possible should be captured)
2) Edge point should be accurately localised on the center of the edge
3) A given edge in the image should only be marked once.

Description of Code :-

```
#include <unistd.h>
#include <stdio.h>
#include <stdlib.h>
#include <iostream>
#include <opencv/highgui.h>
#include <opencv2/core/core.hpp>
#include <opencv2/highgui/highgui.hpp>
#include <opencv2/imgproc/imgproc.hpp>
```

In the initial phase , we have declared all the libraries which are used for the opencv3.

```
#define HRES 640
#define VRES 480
```

After that , we have written the resolution as 640*480 where 640 is the horizontal resolution and 480 is the vertical resolution

After the declaration of threshold and kernel size we have initialised the frame by giving this command

```
IplImage* frame;
```

```
void CannyThreshold(int, void*)
{
   //Mat mat_frame(frame);
   Mat mat_frame(cvarrToMat(frame));

   cvtColor(mat_frame, timg_gray, CV_RGB2GRAY);

   /// Reduce noise with a kernel 3x3
   blur( timg_gray, canny_frame, Size(3,3) );

   /// Canny detector
   Canny( canny_frame, canny_frame, lowThreshold, 0 , kernel_size );

   /// Using Canny's output as a mask, we display our result
   timg_grad = Scalar::all(0);

   mat_frame.copyTo( timg_grad, canny_frame);

   imshow( timg_window_name, timg_grad );

}
```

In the above function used in code , we have different API's.

Mat function creates a matrix of image. Its structure is like this

```
public Mat(int rows,
        int cols,
        int type)
```

The arrays of rows and columns are converted to matrix by this command.

Next in the line is cvtColor , this is used to transform the mat frame into a gray scale image . RGB image is converted to gray scale using this command.

After this, blur is used to the matrix using the kernel of 3*3 . It also reduces noise.
Now you will be able to see the image in a gray scale with low jitter and finally we can use the canny detector function.

Scaler::all(0) fills with 0 and thus making the image black after which we use imshow to display the image.

In the main function , we have used a trackbar to reduce and increase the value of canny threshold. In this we have different threshold values which are used for different image parameters.

In the end we have used cvReleaseCapture(&capture); to release the image on the screen , if we dont use this then the video will never get stopped.

This is how edge detection is performed on a numerous image frames captured continuously.

If we use continuous transformation we can measure the edges on a continuous basis so that whenever there is a change in the captured frame we can easily capture the new edge detected . We can also know the average time response and the deadlines missed by this method. Moreover, as we change the resolution of the image the total number of data size increases, which in turn increases the transformation size of the picture, which finally increases the cpu utility percentage.

Q-5

For this Question, I have selected three algorithms

1) Canny Transformation
2) Hough Lines
3) Hough Circle

//All codes are modification of Professor Sam Siewert's Code

Algorithm analysis :-

In these codes , I have taken 5 resolutions and according to those resolutions I have chosen the deadline and found the average fps of 10 frame. The average frame time is in ms. I have taken deadline by taking 20% more than the Average Frame time. In some cases deadlines are passes, in some it is not passed. If the number of deadlines passed are too much then we cannot say that it is a Hard Real time system.

Things observed :-

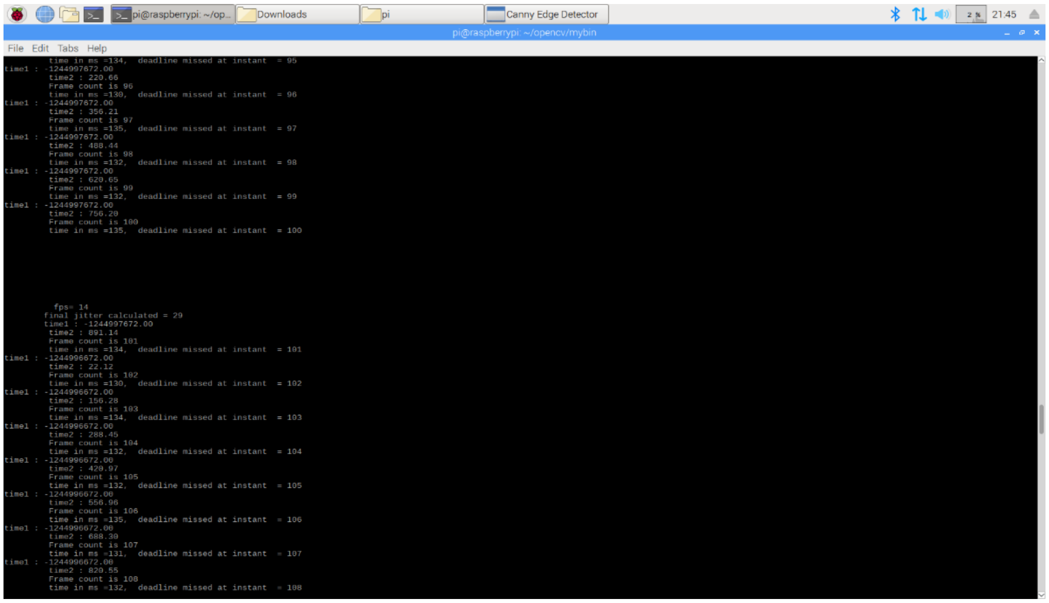
I observed in these codes that , as out resolution increases our fps decreases and out average frame time increases. Average frame time increases because the number of frames to be modified and calculated are more In higher resolution as compared to lower resolution.

Jitter measured is in ms.

1) Canny Transformation :-

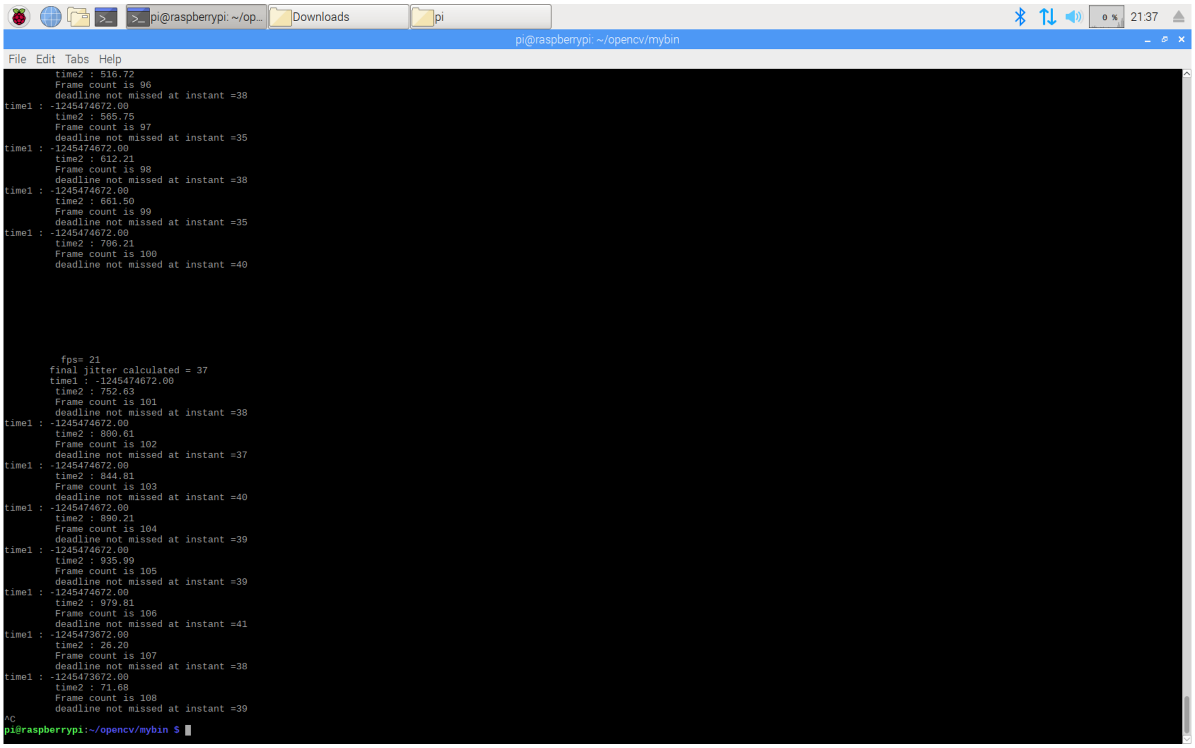
.

Resolution	Average Time Frame	FPS
80*60	35.7 (Deadline:- 42.84)	28 (Jitter = 45)
160*120	37.5 (45)	27 (45)
320*240	47.6(57.14)	21 (37)
500*375	71.6(85.7)	14 (29)
640*480	76.9(92.3)	13 (7)



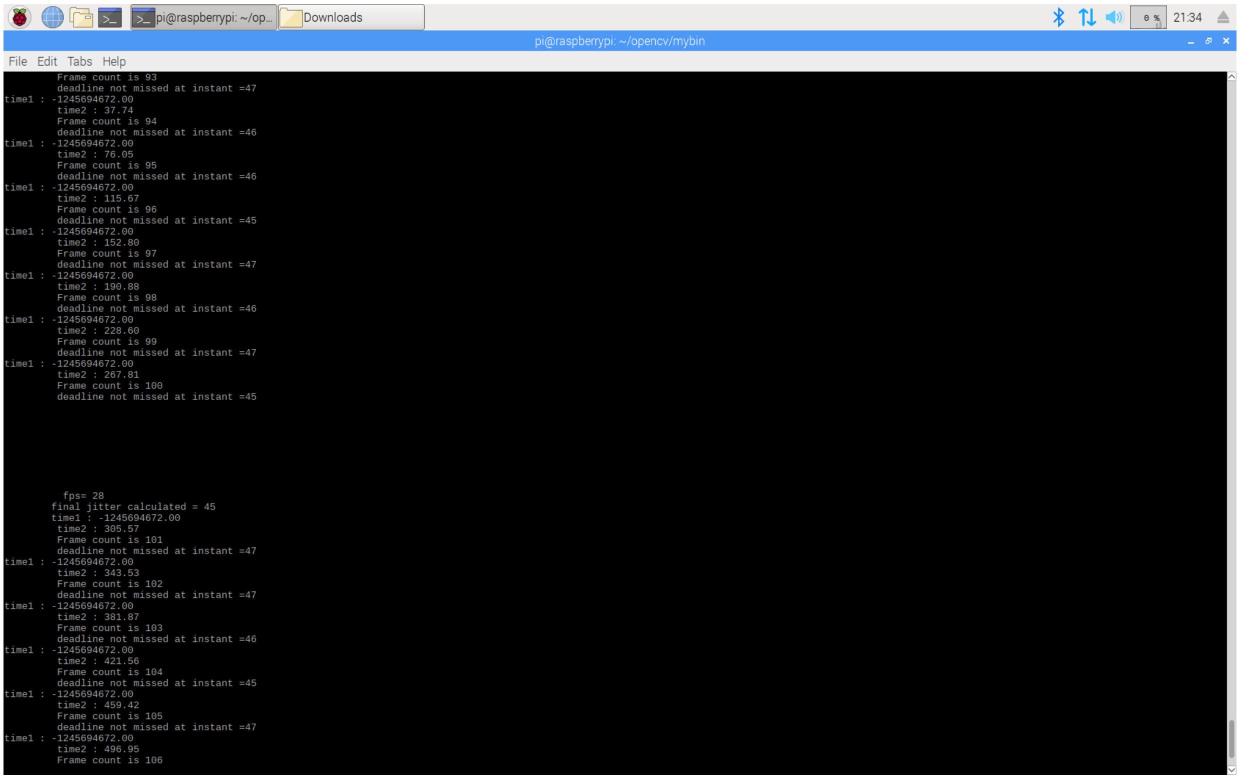
```
         time in ms =134,  deadline missed at instant  = 95
time1 : -1244997672.00
         time2 : 220.66
         Frame count is 96
         time in ms =130,  deadline missed at instant  = 96
time1 : -1244997672.00
         time2 : 356.21
         Frame count is 97
         time in ms =135,  deadline missed at instant  = 97
time1 : -1244997672.00
         time2 : 488.44
         Frame count is 98
         time in ms =132,  deadline missed at instant  = 98
time1 : -1244997672.00
         time2 : 620.65
         Frame count is 99
         time in ms =132,  deadline missed at instant  = 99
time1 : -1244997672.00
         time2 : 756.20
         Frame count is 100
         time in ms =135,  deadline missed at instant  = 100




          fps= 14
        final jitter calculated = 29
        time1 : -1244997672.00
         time2 : 891.14
         Frame count is 101
         time in ms =134,  deadline missed at instant  = 101
time1 : -1244996672.00
         time2 : 22.12
         Frame count is 102
         time in ms =130,  deadline missed at instant  = 102
time1 : -1244996672.00
         time2 : 156.28
         Frame count is 103
         time in ms =134,  deadline missed at instant  = 103
time1 : -1244996672.00
         time2 : 288.45
         Frame count is 104
         time in ms =132,  deadline missed at instant  = 104
time1 : -1244996672.00
         time2 : 420.97
         Frame count is 105
         time in ms =132,  deadline missed at instant  = 105
time1 : -1244996672.00
         time2 : 556.96
         Frame count is 106
         time in ms =135,  deadline missed at instant  = 106
time1 : -1244996672.00
         time2 : 688.30
         Frame count is 107
         time in ms =131,  deadline missed at instant  = 107
time1 : -1244996672.00
         time2 : 820.55
         Frame count is 108
         time in ms =132,  deadline missed at instant  = 108
```

Fig :- 11 500*375 Canny



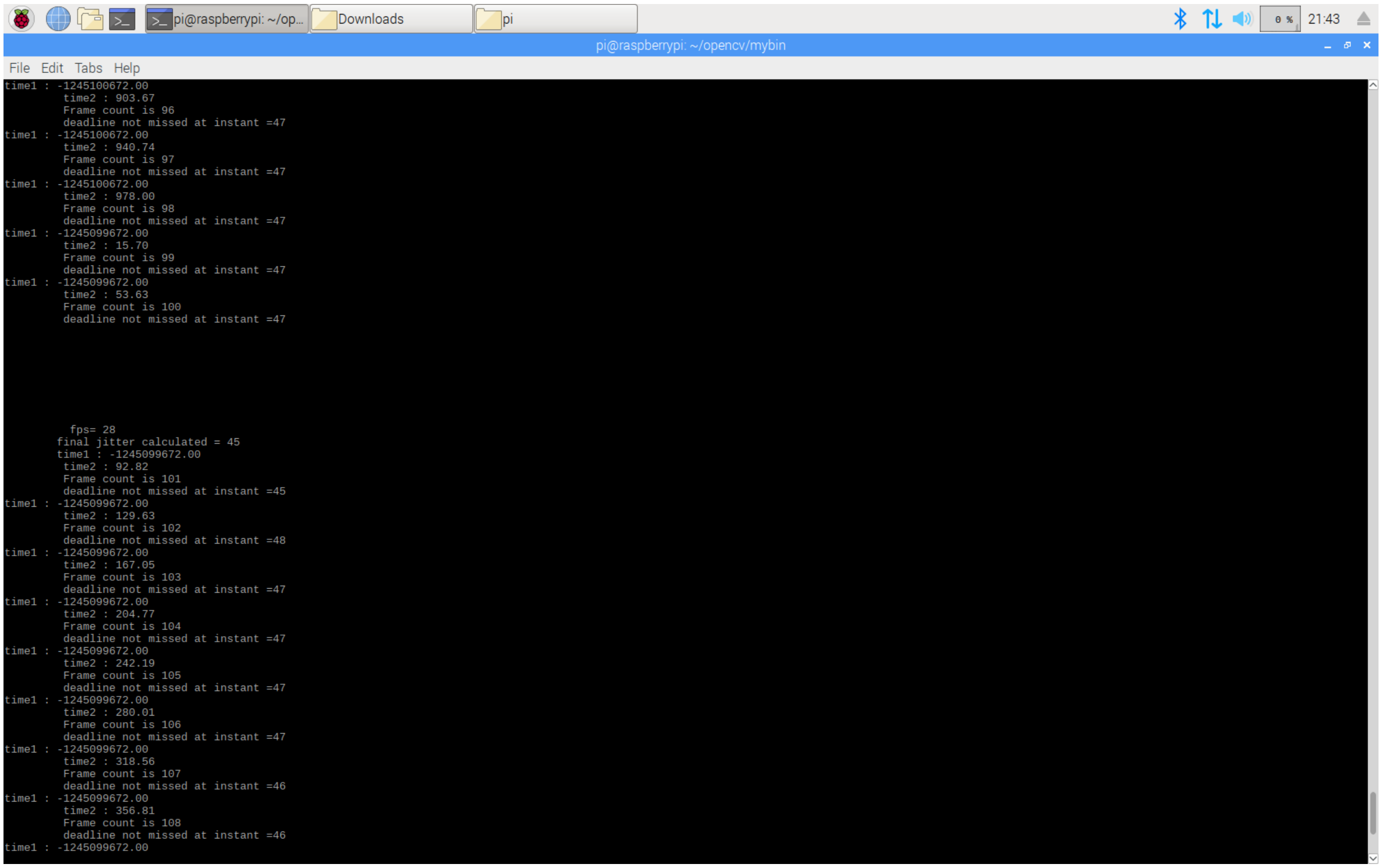
```
         time2 : 516.72
         Frame count is 96
         deadline not missed at instant =38
time1 : -1245474672.00
         time2 : 565.75
         Frame count is 97
         deadline not missed at instant =35
time1 : -1245474672.00
         time2 : 612.21
         Frame count is 98
         deadline not missed at instant =38
time1 : -1245474672.00
         time2 : 661.50
         Frame count is 99
         deadline not missed at instant =35
time1 : -1245474672.00
         time2 : 706.21
         Frame count is 100
         deadline not missed at instant =40








          fps= 21
        final jitter calculated = 37
        time1 : -1245474672.00
         time2 : 752.63
         Frame count is 101
         deadline not missed at instant =38
time1 : -1245474672.00
         time2 : 800.61
         Frame count is 102
         deadline not missed at instant =37
time1 : -1245474672.00
         time2 : 844.81
         Frame count is 103
         deadline not missed at instant =40
time1 : -1245474672.00
         time2 : 890.21
         Frame count is 104
         deadline not missed at instant =39
time1 : -1245474672.00
         time2 : 935.99
         Frame count is 105
         deadline not missed at instant =39
time1 : -1245474672.00
         time2 : 979.81
         Frame count is 106
         deadline not missed at instant =41
time1 : -1245473672.00
         time2 : 26.20
         Frame count is 107
         deadline not missed at instant =38
time1 : -1245473672.00
         time2 : 71.68
         Frame count is 108
         deadline not missed at instant =39
^C
pi@raspberrypi:~/opencv/mybin $ 
```

Fig 12 :- 320*240 Canny



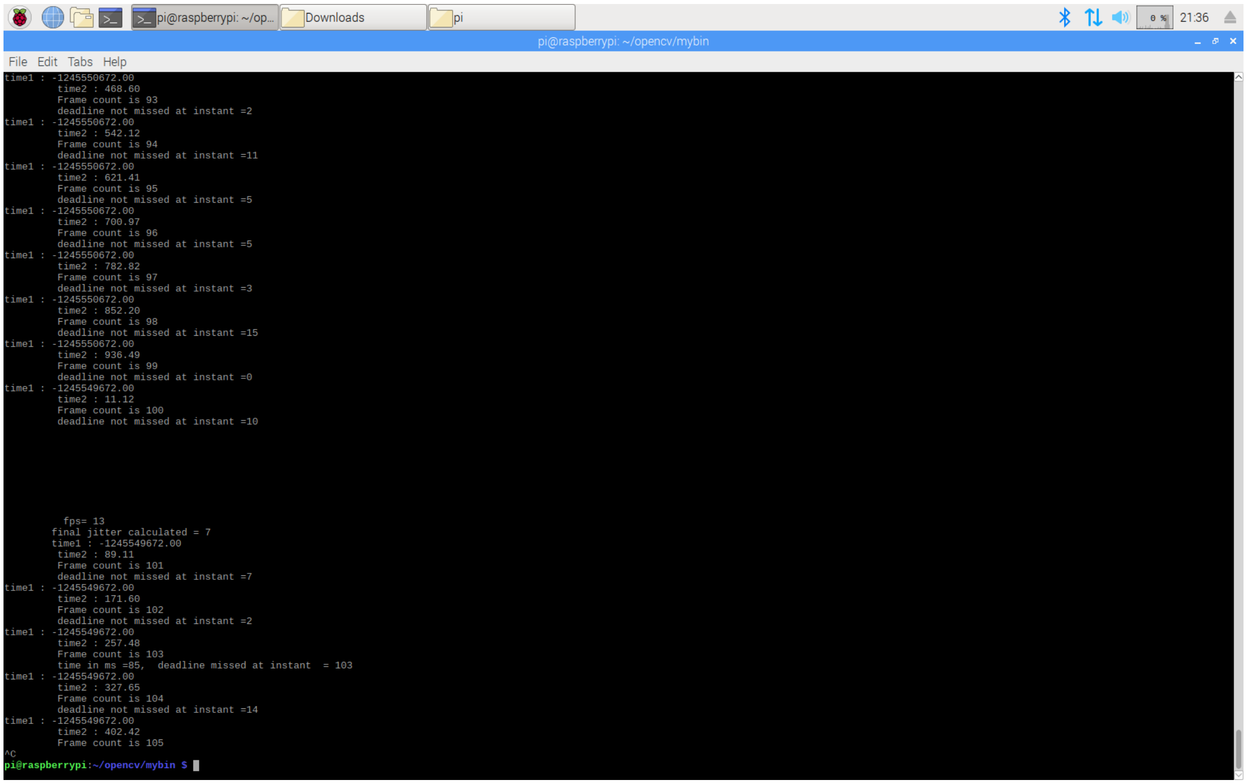
```
         Frame count is 93
         deadline not missed at instant =47
time1 : -1245694672.00
         time2 : 37.74
         Frame count is 94
         deadline not missed at instant =46
time1 : -1245694672.00
         time2 : 76.05
         Frame count is 95
         deadline not missed at instant =46
time1 : -1245694672.00
         time2 : 115.67
         Frame count is 96
         deadline not missed at instant =45
time1 : -1245694672.00
         time2 : 152.80
         Frame count is 97
         deadline not missed at instant =47
time1 : -1245694672.00
         time2 : 190.88
         Frame count is 98
         deadline not missed at instant =46
time1 : -1245694672.00
         time2 : 228.60
         Frame count is 99
         deadline not missed at instant =47
time1 : -1245694672.00
         time2 : 267.81
         Frame count is 100
         deadline not missed at instant =45








          fps= 28
        final jitter calculated = 45
        time1 : -1245694672.00
         time2 : 305.57
         Frame count is 101
         deadline not missed at instant =47
time1 : -1245694672.00
         time2 : 343.53
         Frame count is 102
         deadline not missed at instant =47
time1 : -1245694672.00
         time2 : 381.87
         Frame count is 103
         deadline not missed at instant =46
time1 : -1245694672.00
         time2 : 421.56
         Frame count is 104
         deadline not missed at instant =45
time1 : -1245694672.00
         time2 : 459.42
         Frame count is 105
         deadline not missed at instant =47
time1 : -1245694672.00
         time2 : 496.95
         Frame count is 106
```

Fig :13 160*120 Canny



```
time1 : -1245100672.00
         time2 : 903.67
         Frame count is 96
         deadline not missed at instant =47
time1 : -1245100672.00
         time2 : 940.74
         Frame count is 97
         deadline not missed at instant =47
time1 : -1245100672.00
         time2 : 978.00
         Frame count is 98
         deadline not missed at instant =47
time1 : -1245099672.00
         time2 : 15.70
         Frame count is 99
         deadline not missed at instant =47
time1 : -1245099672.00
         time2 : 53.63
         Frame count is 100
         deadline not missed at instant =47








          fps= 28
        final jitter calculated = 45
        time1 : -1245099672.00
         time2 : 92.82
         Frame count is 101
         deadline not missed at instant =45
time1 : -1245099672.00
         time2 : 129.63
         Frame count is 102
         deadline not missed at instant =48
time1 : -1245099672.00
         time2 : 167.05
         Frame count is 103
         deadline not missed at instant =47
time1 : -1245099672.00
         time2 : 204.77
         Frame count is 104
         deadline not missed at instant =47
time1 : -1245099672.00
         time2 : 242.19
         Frame count is 105
         deadline not missed at instant =47
time1 : -1245099672.00
         time2 : 280.01
         Frame count is 106
         deadline not missed at instant =47
time1 : -1245099672.00
         time2 : 318.56
         Frame count is 107
         deadline not missed at instant =46
time1 : -1245099672.00
         time2 : 356.81
         Frame count is 108
         deadline not missed at instant =46
time1 : -1245099672.00
```

Fig 14 80*20 Canny

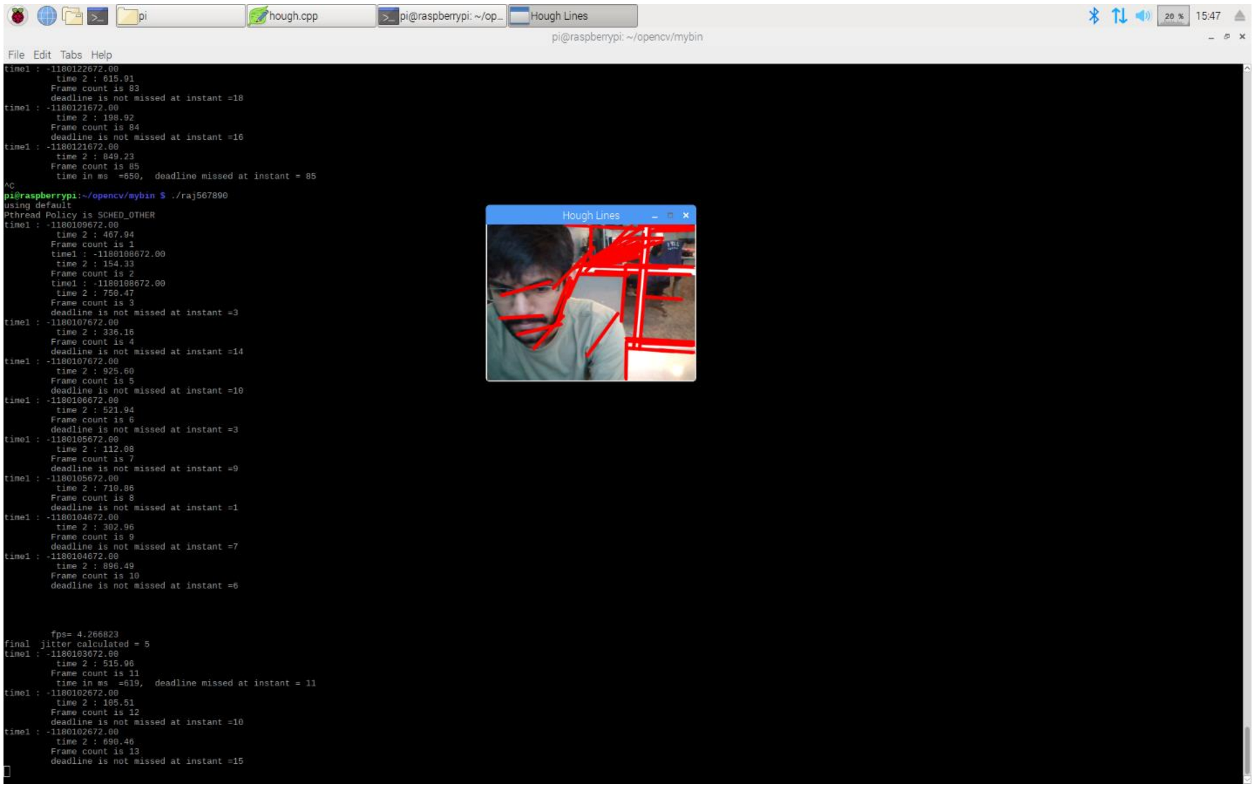


```
time1 : -1245550672.00
         time2 : 468.60
         Frame count is 93
         deadline not missed at instant =2
time1 : -1245550672.00
         time2 : 542.12
         Frame count is 94
         deadline not missed at instant =11
time1 : -1245550672.00
         time2 : 621.41
         Frame count is 95
         deadline not missed at instant =5
time1 : -1245550672.00
         time2 : 700.97
         Frame count is 96
         deadline not missed at instant =5
time1 : -1245550672.00
         time2 : 782.82
         Frame count is 97
         deadline not missed at instant =3
time1 : -1245550672.00
         time2 : 852.20
         Frame count is 98
         deadline not missed at instant =15
time1 : -1245550672.00
         time2 : 936.49
         Frame count is 99
         deadline not missed at instant =0
time1 : -1245549672.00
         time2 : 11.12
         Frame count is 100
         deadline not missed at instant =10








          fps= 13
        final jitter calculated = 7
        time1 : -1245549672.00
         time2 : 89.11
         Frame count is 101
         deadline not missed at instant =7
time1 : -1245549672.00
         time2 : 171.60
         Frame count is 102
         deadline not missed at instant =2
time1 : -1245549672.00
         time2 : 257.48
         Frame count is 103
         time in ms =85,  deadline missed at instant  = 103
time1 : -1245549672.00
         time2 : 327.65
         Frame count is 104
         deadline not missed at instant =14
time1 : -1245549672.00
         time2 : 402.42
         Frame count is 105
^C
pi@raspberrypi:~/opencv/mybin $ 
```

Fig 16 **640*480 Canny**

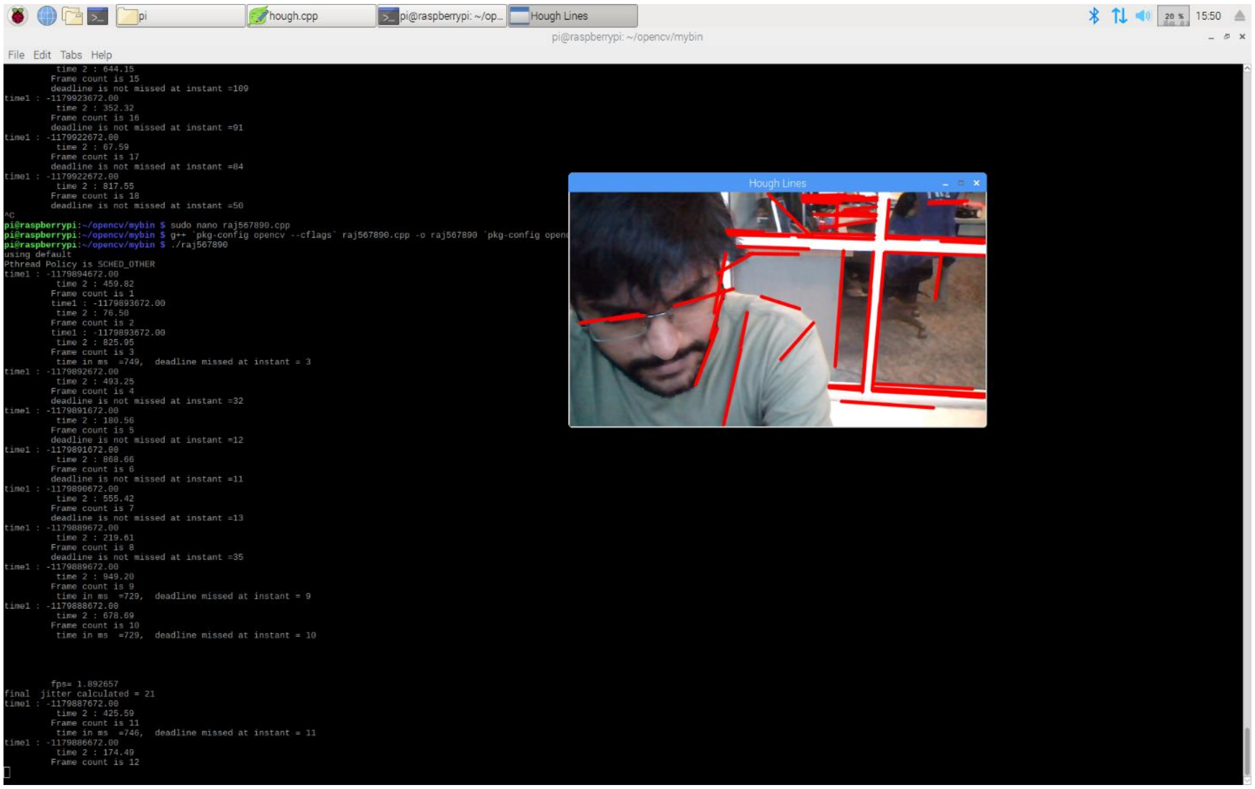
2) HoughLines:-

Resolution	Average Time Frame	FPS
320*240	234 (Deadline:- 280)	4.266 (Jitter = 5)
500*375	529 (635)	1.89 (21)
640*480	584 (700)	1.712 (46)
1120*840	591 (700)	1.69 (23)
1440*1080	1388 (1660)	0.72 (49)



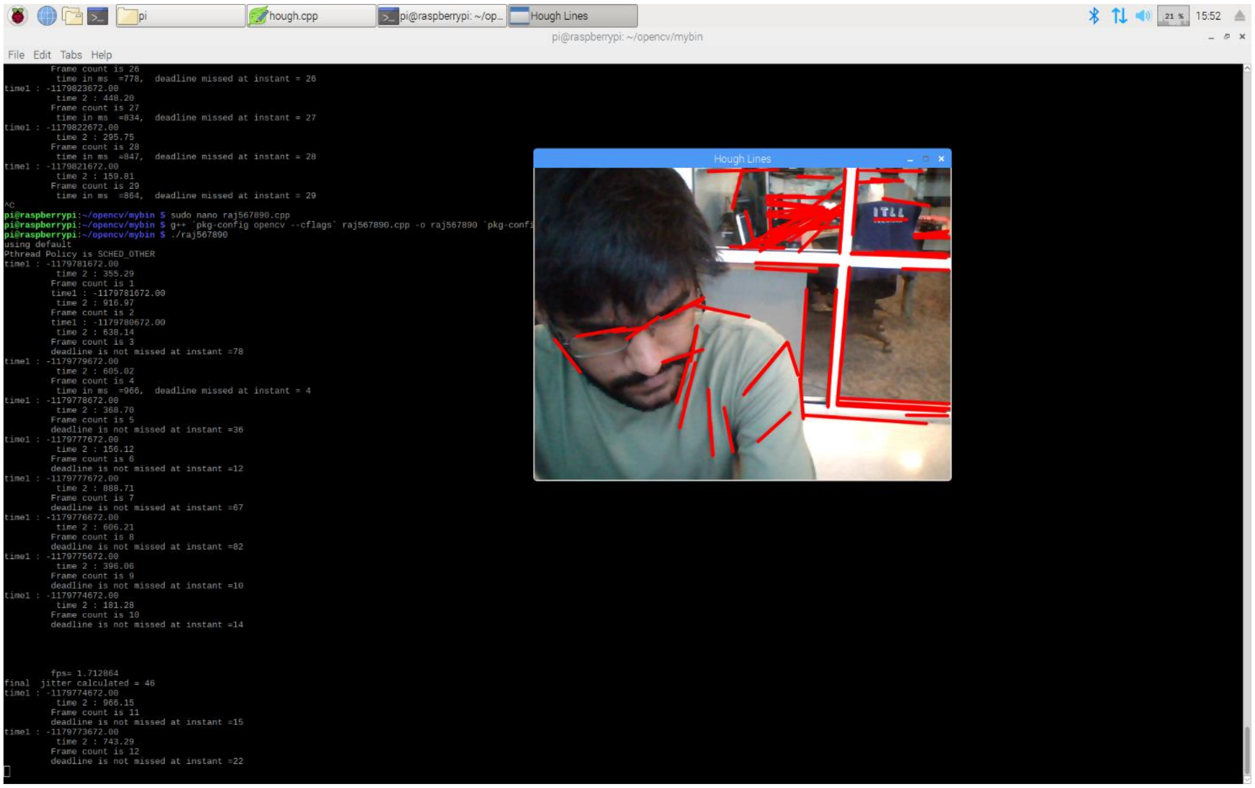
```
time1 : -1180122672.00
          time 2 : 615.91
         Frame count is 83
         deadline is not missed at instant =18
time1 : -1180121672.00
          time 2 : 198.92
         Frame count is 84
         deadline is not missed at instant =16
time1 : -1180121672.00
          time 2 : 849.23
         Frame count is 85
          time in ms  =650,  deadline missed at instant = 85
^C
pi@raspberrypi:~/opencv/mybin $ ./raj567890
using default
Pthread Policy is SCHED_OTHER
time1 : -1180109672.00
          time 2 : 467.94
         Frame count is 1
         time1 : -1180108672.00
          time 2 : 154.33
         Frame count is 2
         time1 : -1180108672.00
          time 2 : 750.47
         Frame count is 3
         deadline is not missed at instant =3
time1 : -1180107672.00
          time 2 : 336.16
         Frame count is 4
         deadline is not missed at instant =14
time1 : -1180107672.00
          time 2 : 925.60
         Frame count is 5
         deadline is not missed at instant =10
time1 : -1180106672.00
          time 2 : 521.94
         Frame count is 6
         deadline is not missed at instant =3
time1 : -1180105672.00
          time 2 : 112.08
         Frame count is 7
         deadline is not missed at instant =9
time1 : -1180105672.00
          time 2 : 710.86
         Frame count is 8
         deadline is not missed at instant =1
time1 : -1180104672.00
          time 2 : 302.96
         Frame count is 9
         deadline is not missed at instant =7
time1 : -1180104672.00
          time 2 : 896.49
         Frame count is 10
         deadline is not missed at instant =6



         fps= 4.266823
final  jitter calculated = 5
time1 : -1180103672.00
          time 2 : 515.96
         Frame count is 11
          time in ms  =619,  deadline missed at instant = 11
time1 : -1180102672.00
          time 2 : 105.51
         Frame count is 12
         deadline is not missed at instant =10
time1 : -1180102672.00
          time 2 : 690.46
         Frame count is 13
         deadline is not missed at instant =15
```

Fig 17:-   320*240 Lines



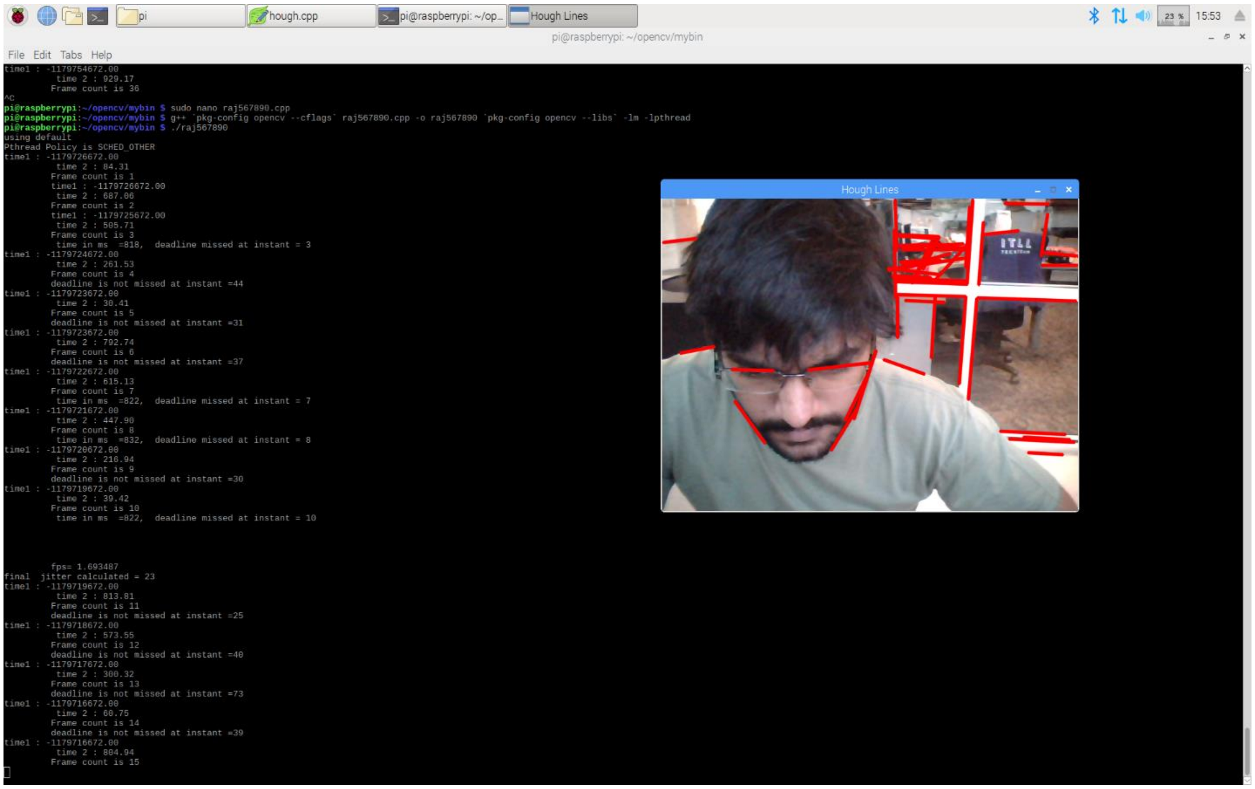
```
          time 2 : 644.15
         Frame count is 15
         deadline is not missed at instant =109
time1 : -1179923672.00
          time 2 : 352.32
         Frame count is 16
         deadline is not missed at instant =91
time1 : -1179922672.00
          time 2 : 67.59
         Frame count is 17
         deadline is not missed at instant =84
time1 : -1179922672.00
          time 2 : 817.55
         Frame count is 18
         deadline is not missed at instant =50
^C
pi@raspberrypi:~/opencv/mybin $ sudo nano raj567890.cpp
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflags` raj567890.cpp -o raj567890 `pkg-config open
pi@raspberrypi:~/opencv/mybin $ ./raj567890
using default
Pthread Policy is SCHED_OTHER
time1 : -1179894672.00
          time 2 : 459.82
         Frame count is 1
         time1 : -1179893672.00
          time 2 : 76.50
         Frame count is 2
         time1 : -1179893672.00
          time 2 : 825.95
         Frame count is 3
          time in ms  =749,  deadline missed at instant = 3
time1 : -1179892672.00
          time 2 : 493.25
         Frame count is 4
         deadline is not missed at instant =32
time1 : -1179891672.00
          time 2 : 180.56
         Frame count is 5
         deadline is not missed at instant =12
time1 : -1179891672.00
          time 2 : 868.66
         Frame count is 6
         deadline is not missed at instant =11
time1 : -1179890672.00
          time 2 : 555.42
         Frame count is 7
         deadline is not missed at instant =13
time1 : -1179889672.00
          time 2 : 219.61
         Frame count is 8
         deadline is not missed at instant =35
time1 : -1179889672.00
          time 2 : 949.20
         Frame count is 9
          time in ms  =729,  deadline missed at instant = 9
time1 : -1179888672.00
          time 2 : 678.69
         Frame count is 10
          time in ms  =729,  deadline missed at instant = 10



         fps= 1.892657
final  jitter calculated = 21
time1 : -1179887672.00
          time 2 : 425.59
         Frame count is 11
          time in ms  =746,  deadline missed at instant = 11
time1 : -1179886672.00
          time 2 : 174.49
         Frame count is 12
```

Fig 18 :-   500*375



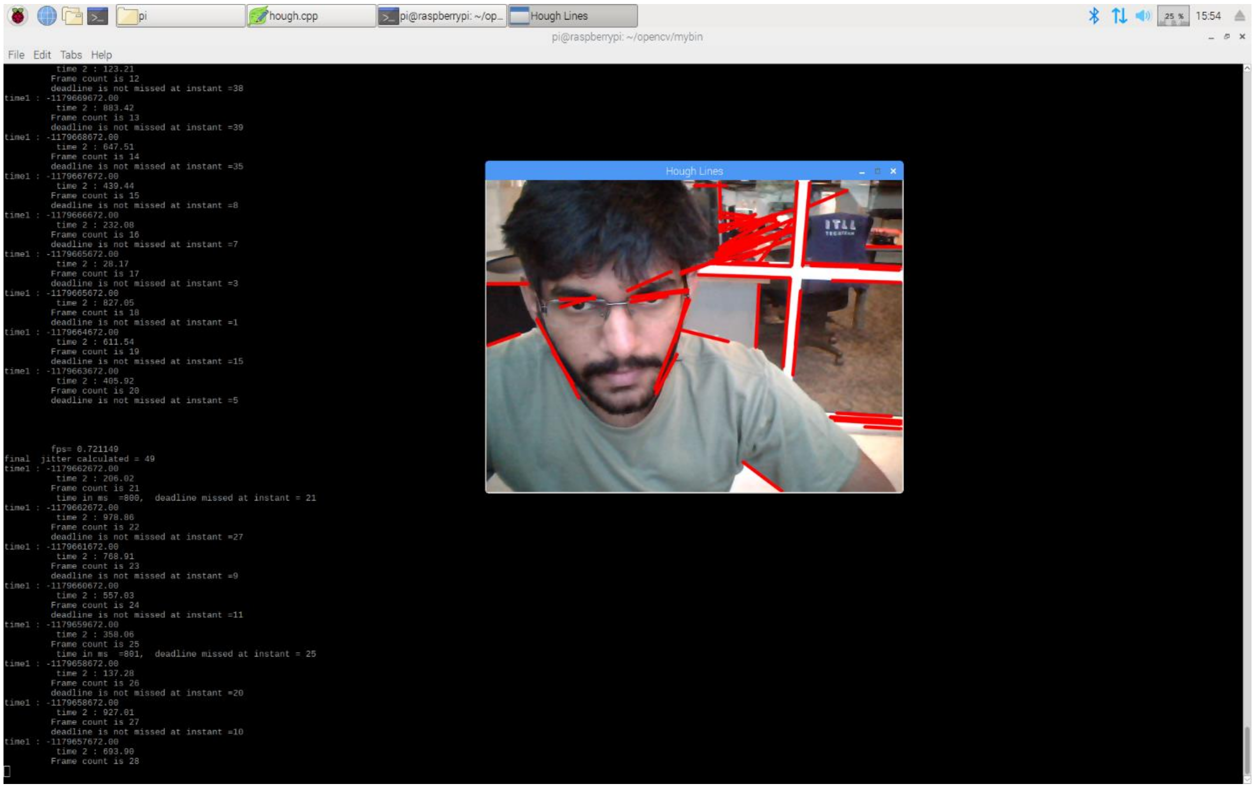
```
        Frame count is 26
         time in ms  =778,  deadline missed at instant = 26
time1 : -1179823672.00
         time 2 : 448.20
        Frame count is 27
         time in ms  =834,  deadline missed at instant = 27
time1 : -1179822672.00
         time 2 : 295.75
        Frame count is 28
         time in ms  =847,  deadline missed at instant = 28
time1 : -1179821672.00
         time 2 : 159.81
        Frame count is 29
         time in ms  =864,  deadline missed at instant = 29
^C
pi@raspberrypi:~/opencv/mybin $ sudo nano raj567890.cpp
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflags` raj567890.cpp -o raj567890 `pkg-confi
pi@raspberrypi:~/opencv/mybin $ ./raj567890
using default
Pthread Policy is SCHED_OTHER
time1 : -1179781672.00
         time 2 : 355.29
        Frame count is 1
        time1 : -1179781672.00
         time 2 : 916.97
        Frame count is 2
        time1 : -1179780672.00
         time 2 : 638.14
        Frame count is 3
        deadline is not missed at instant =78
time1 : -1179779672.00
         time 2 : 605.02
        Frame count is 4
         time in ms  =966,  deadline missed at instant = 4
time1 : -1179778672.00
         time 2 : 368.70
        Frame count is 5
        deadline is not missed at instant =36
time1 : -1179777672.00
         time 2 : 156.12
        Frame count is 6
        deadline is not missed at instant =12
time1 : -1179777672.00
         time 2 : 888.71
        Frame count is 7
        deadline is not missed at instant =67
time1 : -1179776672.00
         time 2 : 606.21
        Frame count is 8
        deadline is not missed at instant =82
time1 : -1179775672.00
         time 2 : 396.06
        Frame count is 9
        deadline is not missed at instant =10
time1 : -1179774672.00
         time 2 : 181.28
        Frame count is 10
        deadline is not missed at instant =14



        fps= 1.712864
final  jitter calculated = 46
time1 : -1179774672.00
         time 2 : 966.15
        Frame count is 11
        deadline is not missed at instant =15
time1 : -1179773672.00
         time 2 : 743.29
        Frame count is 12
        deadline is not missed at instant =22
```

Fig 19 :-   640*480 Lines



```
time1 : -1179754672.00
         time 2 : 929.17
        Frame count is 36
^C
pi@raspberrypi:~/opencv/mybin $ sudo nano raj567890.cpp
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflags` raj567890.cpp -o raj567890 `pkg-config opencv --libs` -lm -lpthread
pi@raspberrypi:~/opencv/mybin $ ./raj567890
using default
Pthread Policy is SCHED_OTHER
time1 : -1179726672.00
         time 2 : 84.31
        Frame count is 1
        time1 : -1179726672.00
         time 2 : 687.06
        Frame count is 2
        time1 : -1179725672.00
         time 2 : 505.71
        Frame count is 3
         time in ms  =818,  deadline missed at instant = 3
time1 : -1179724672.00
         time 2 : 261.53
        Frame count is 4
        deadline is not missed at instant =44
time1 : -1179723672.00
         time 2 : 30.41
        Frame count is 5
        deadline is not missed at instant =31
time1 : -1179723672.00
         time 2 : 792.74
        Frame count is 6
        deadline is not missed at instant =37
time1 : -1179722672.00
         time 2 : 615.13
        Frame count is 7
         time in ms  =822,  deadline missed at instant = 7
time1 : -1179721672.00
         time 2 : 447.90
        Frame count is 8
         time in ms  =832,  deadline missed at instant = 8
time1 : -1179720672.00
         time 2 : 216.94
        Frame count is 9
        deadline is not missed at instant =30
time1 : -1179719672.00
         time 2 : 39.42
        Frame count is 10
         time in ms  =822,  deadline missed at instant = 10



        fps= 1.693487
final  jitter calculated = 23
time1 : -1179719672.00
         time 2 : 813.81
        Frame count is 11
        deadline is not missed at instant =25
time1 : -1179718672.00
         time 2 : 573.55
        Frame count is 12
        deadline is not missed at instant =40
time1 : -1179717672.00
         time 2 : 300.32
        Frame count is 13
        deadline is not missed at instant =73
time1 : -1179716672.00
         time 2 : 60.75
        Frame count is 14
        deadline is not missed at instant =39
time1 : -1179716672.00
         time 2 : 804.94
        Frame count is 15
```

Fig 20 :- 1120*840 Lines

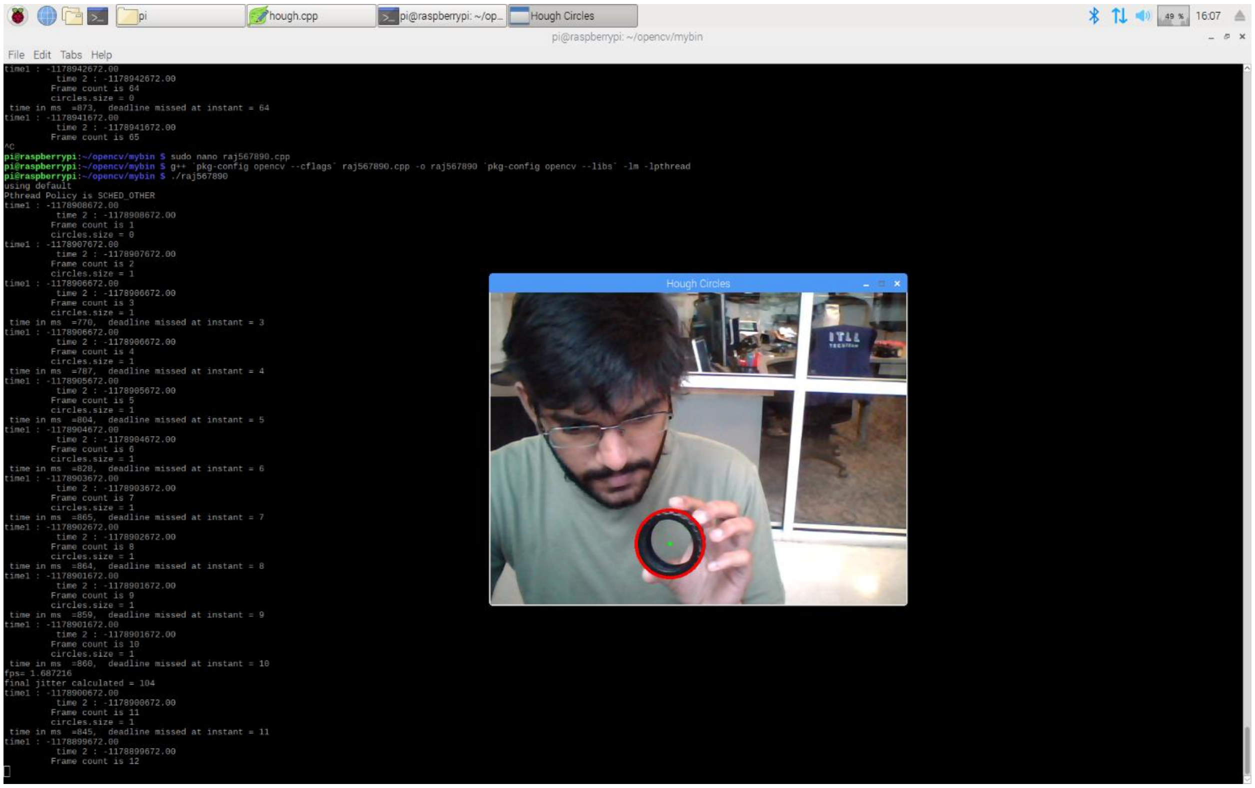


```
         time 2 : 123.21
        Frame count is 12
        deadline is not missed at instant =38
time1 : -1179669672.00
         time 2 : 883.42
        Frame count is 13
        deadline is not missed at instant =39
time1 : -1179668672.00
         time 2 : 647.51
        Frame count is 14
        deadline is not missed at instant =35
time1 : -1179667672.00
         time 2 : 439.44
        Frame count is 15
        deadline is not missed at instant =8
time1 : -1179666672.00
         time 2 : 232.08
        Frame count is 16
        deadline is not missed at instant =7
time1 : -1179665672.00
         time 2 : 28.17
        Frame count is 17
        deadline is not missed at instant =3
time1 : -1179665672.00
         time 2 : 827.05
        Frame count is 18
        deadline is not missed at instant =1
time1 : -1179664672.00
         time 2 : 611.54
        Frame count is 19
        deadline is not missed at instant =15
time1 : -1179663672.00
         time 2 : 405.92
        Frame count is 20
        deadline is not missed at instant =5



        fps= 0.721149
final  jitter calculated = 49
time1 : -1179662672.00
         time 2 : 206.02
        Frame count is 21
         time in ms  =800,  deadline missed at instant = 21
time1 : -1179662672.00
         time 2 : 978.86
        Frame count is 22
        deadline is not missed at instant =27
time1 : -1179661672.00
         time 2 : 768.91
        Frame count is 23
        deadline is not missed at instant =9
time1 : -1179660672.00
         time 2 : 557.03
        Frame count is 24
        deadline is not missed at instant =11
time1 : -1179659672.00
         time 2 : 358.06
        Frame count is 25
         time in ms  =801,  deadline missed at instant = 25
time1 : -1179658672.00
         time 2 : 137.28
        Frame count is 26
        deadline is not missed at instant =20
time1 : -1179658672.00
         time 2 : 927.01
        Frame count is 27
        deadline is not missed at instant =10
time1 : -1179657672.00
         time 2 : 693.90
        Frame count is 28
```

Fig :- 21 1440*1080 Lines

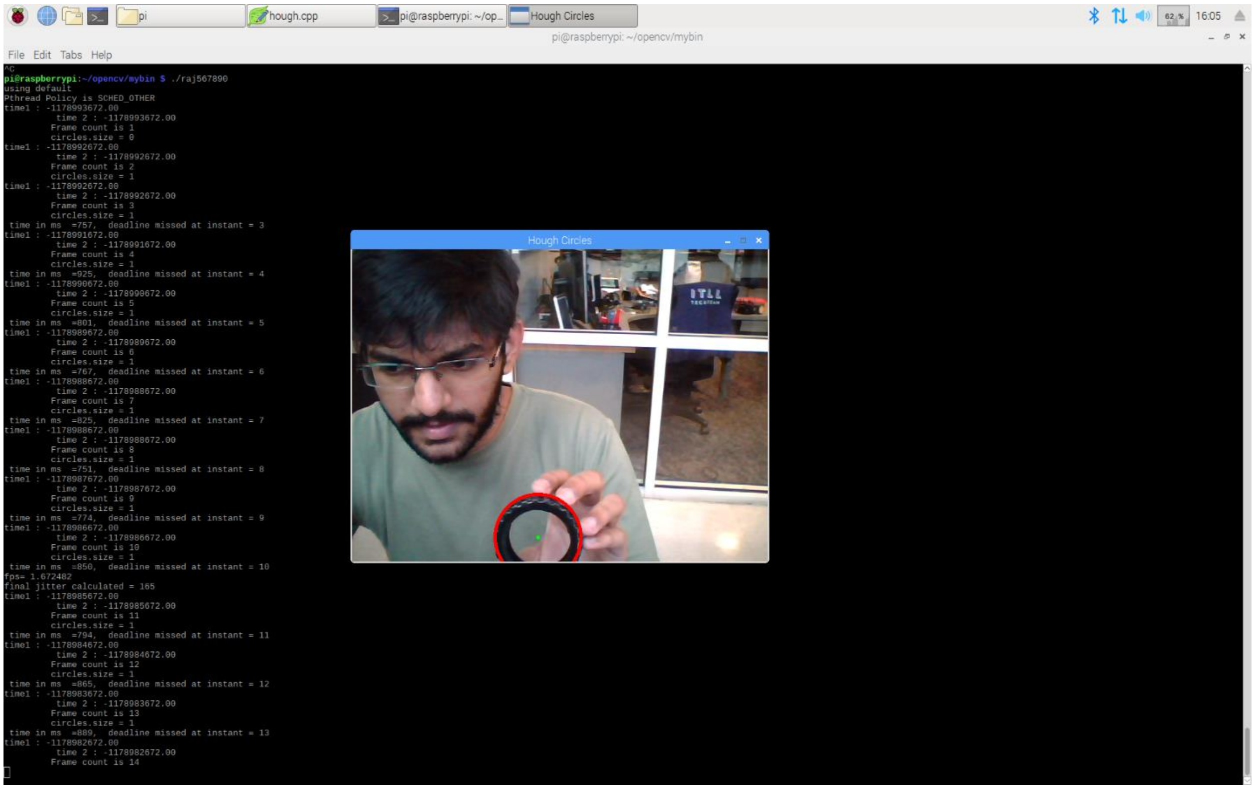
3) Hough Circle :-

Resolution	Average Time Frame	FPS
320*240	335 (Deadline:- 402)	2.98 (Jitter = 118)
640*480	465 (558)	2.15 (41)
960*720	378(453)	2.64 (112)
1120*840	591 (710)	1.69 (104)
1440*1080	598 (717)	1.67 (165)



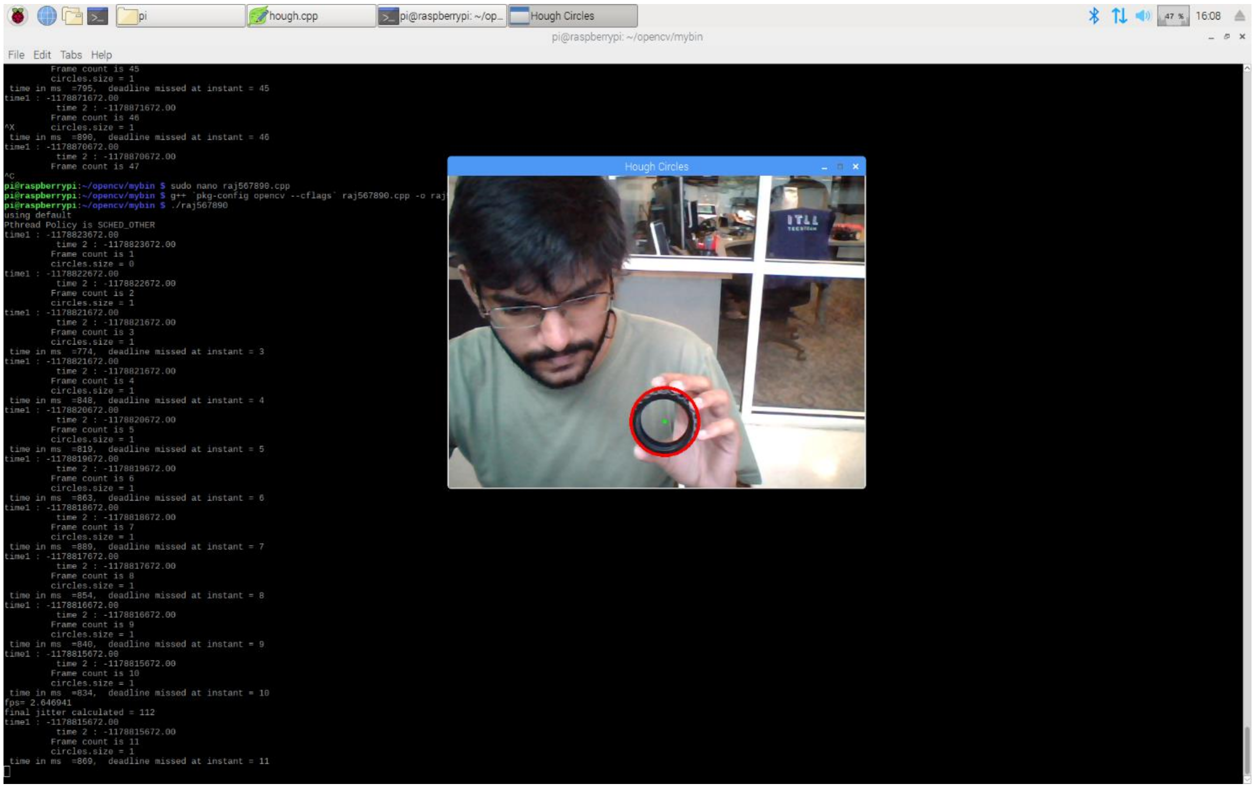
```
time1 : -1178942672.00
         time 2 : -1178942672.00
        Frame count is 64
        circles.size = 0
 time in ms  =873,  deadline missed at instant = 64
time1 : -1178941672.00
         time 2 : -1178941672.00
        Frame count is 65
^C
pi@raspberrypi:~/opencv/mybin $ sudo nano raj567890.cpp
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflags` raj567890.cpp -o raj567890 `pkg-config opencv --libs` -lm -lpthread
pi@raspberrypi:~/opencv/mybin $ ./raj567890
using default
Pthread Policy is SCHED_OTHER
time1 : -1178908672.00
         time 2 : -1178908672.00
        Frame count is 1
        circles.size = 0
time1 : -1178907672.00
         time 2 : -1178907672.00
        Frame count is 2
        circles.size = 1
time1 : -1178906672.00
         time 2 : -1178906672.00
        Frame count is 3
        circles.size = 1
 time in ms  =770,  deadline missed at instant = 3
time1 : -1178906672.00
         time 2 : -1178906672.00
        Frame count is 4
        circles.size = 1
 time in ms  =787,  deadline missed at instant = 4
time1 : -1178905672.00
         time 2 : -1178905672.00
        Frame count is 5
        circles.size = 1
 time in ms  =804,  deadline missed at instant = 5
time1 : -1178904672.00
         time 2 : -1178904672.00
        Frame count is 6
        circles.size = 1
 time in ms  =828,  deadline missed at instant = 6
time1 : -1178903672.00
         time 2 : -1178903672.00
        Frame count is 7
        circles.size = 1
 time in ms  =865,  deadline missed at instant = 7
time1 : -1178902672.00
         time 2 : -1178902672.00
        Frame count is 8
        circles.size = 1
 time in ms  =864,  deadline missed at instant = 8
time1 : -1178901672.00
         time 2 : -1178901672.00
        Frame count is 9
        circles.size = 1
 time in ms  =859,  deadline missed at instant = 9
time1 : -1178901672.00
         time 2 : -1178901672.00
        Frame count is 10
        circles.size = 1
 time in ms  =860,  deadline missed at instant = 10
fps= 1.687216
final jitter calculated = 104
time1 : -1178900672.00
         time 2 : -1178900672.00
        Frame count is 11
        circles.size = 1
 time in ms  =845,  deadline missed at instant = 11
time1 : -1178899672.00
         time 2 : -1178899672.00
        Frame count is 12
```

Fig :- 22 1120*840 Circle



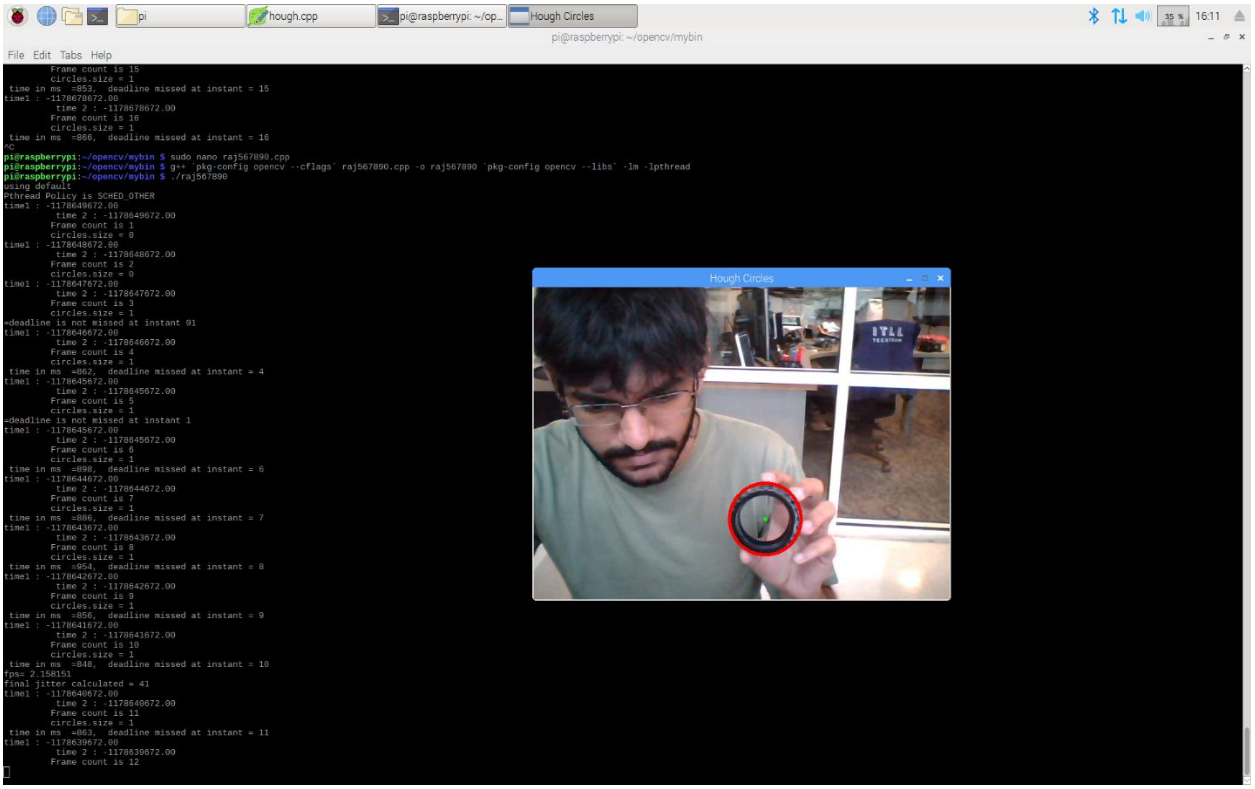
```
^C
pi@raspberrypi:~/opencv/mybin $ ./raj567890
using default
Pthread Policy is SCHED_OTHER
time1 : -1178993672.00
         time 2 : -1178993672.00
        Frame count is 1
        circles.size = 0
time1 : -1178992672.00
         time 2 : -1178992672.00
        Frame count is 2
        circles.size = 1
time1 : -1178992672.00
         time 2 : -1178992672.00
        Frame count is 3
        circles.size = 1
 time in ms  =757,  deadline missed at instant = 3
time1 : -1178991672.00
         time 2 : -1178991672.00
        Frame count is 4
        circles.size = 1
 time in ms  =925,  deadline missed at instant = 4
time1 : -1178990672.00
         time 2 : -1178990672.00
        Frame count is 5
        circles.size = 1
 time in ms  =801,  deadline missed at instant = 5
time1 : -1178989672.00
         time 2 : -1178989672.00
        Frame count is 6
        circles.size = 1
 time in ms  =767,  deadline missed at instant = 6
time1 : -1178988672.00
         time 2 : -1178988672.00
        Frame count is 7
        circles.size = 1
 time in ms  =825,  deadline missed at instant = 7
time1 : -1178988672.00
         time 2 : -1178988672.00
        Frame count is 8
        circles.size = 1
 time in ms  =751,  deadline missed at instant = 8
time1 : -1178987672.00
         time 2 : -1178987672.00
        Frame count is 9
        circles.size = 1
 time in ms  =774,  deadline missed at instant = 9
time1 : -1178986672.00
         time 2 : -1178986672.00
        Frame count is 10
        circles.size = 1
 time in ms  =850,  deadline missed at instant = 10
fps= 1.672482
final jitter calculated = 165
time1 : -1178985672.00
         time 2 : -1178985672.00
        Frame count is 11
        circles.size = 1
 time in ms  =794,  deadline missed at instant = 11
time1 : -1178984672.00
         time 2 : -1178984672.00
        Frame count is 12
        circles.size = 1
 time in ms  =865,  deadline missed at instant = 12
time1 : -1178983672.00
         time 2 : -1178983672.00
        Frame count is 13
        circles.size = 1
 time in ms  =889,  deadline missed at instant = 13
time1 : -1178982672.00
         time 2 : -1178982672.00
        Frame count is 14
```

Fig :- 23 1480*1080 Circle



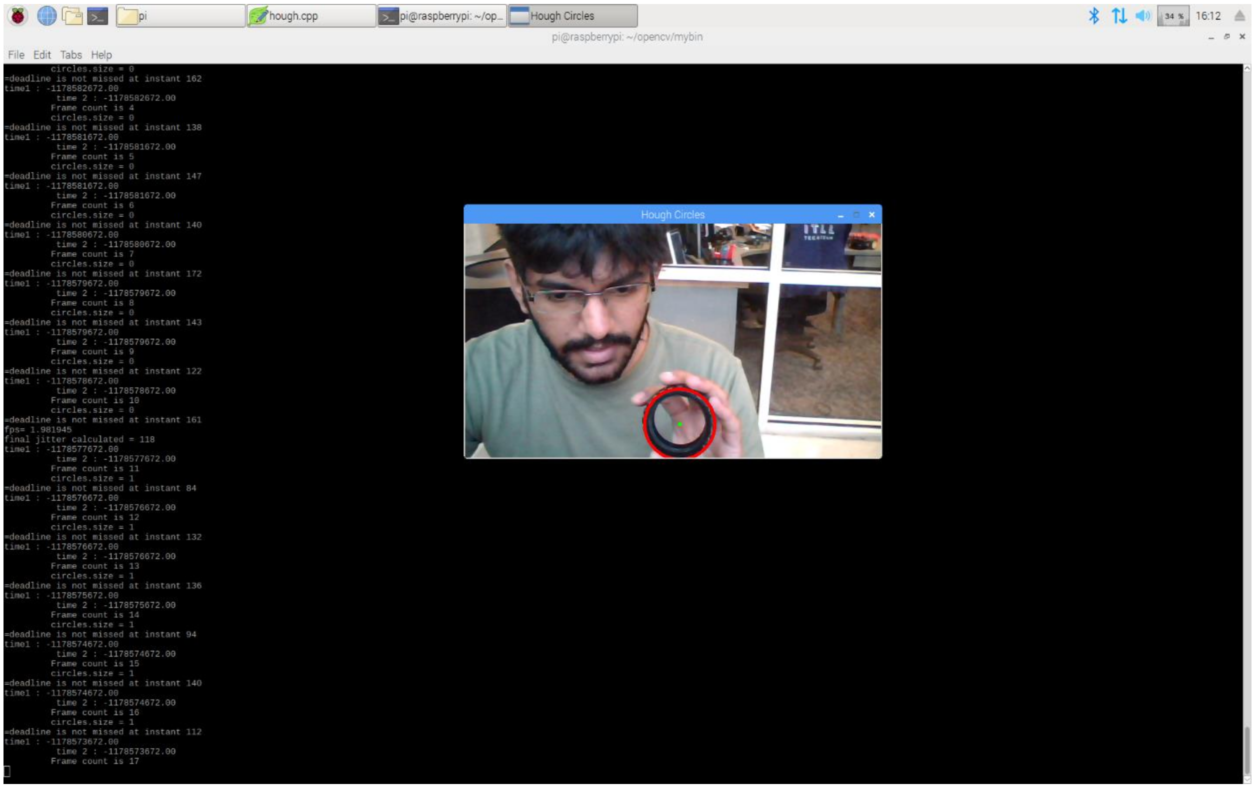
```
          Frame count is 45
          circles.size = 1
 time in ms  =795,  deadline missed at instant = 45
time1 : -1178871672.00
           time 2 : -1178871672.00
          Frame count is 46
^X        circles.size = 1
 time in ms  =890,  deadline missed at instant = 46
time1 : -1178870672.00
           time 2 : -1178870672.00
          Frame count is 47
^C
pi@raspberrypi:~/opencv/mybin $ sudo nano raj567890.cpp
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflags` raj567890.cpp -o raj
pi@raspberrypi:~/opencv/mybin $ ./raj567890
using default
Pthread Policy is SCHED_OTHER
time1 : -1178823672.00
           time 2 : -1178823672.00
          Frame count is 1
          circles.size = 0
time1 : -1178822672.00
           time 2 : -1178822672.00
          Frame count is 2
          circles.size = 1
time1 : -1178821672.00
           time 2 : -1178821672.00
          Frame count is 3
          circles.size = 1
 time in ms  =774,  deadline missed at instant = 3
time1 : -1178821672.00
           time 2 : -1178821672.00
          Frame count is 4
          circles.size = 1
 time in ms  =848,  deadline missed at instant = 4
time1 : -1178820672.00
           time 2 : -1178820672.00
          Frame count is 5
          circles.size = 1
 time in ms  =819,  deadline missed at instant = 5
time1 : -1178819672.00
           time 2 : -1178819672.00
          Frame count is 6
          circles.size = 1
 time in ms  =863,  deadline missed at instant = 6
time1 : -1178818672.00
           time 2 : -1178818672.00
          Frame count is 7
          circles.size = 1
 time in ms  =889,  deadline missed at instant = 7
time1 : -1178817672.00
           time 2 : -1178817672.00
          Frame count is 8
          circles.size = 1
 time in ms  =854,  deadline missed at instant = 8
time1 : -1178816672.00
           time 2 : -1178816672.00
          Frame count is 9
          circles.size = 1
 time in ms  =840,  deadline missed at instant = 9
time1 : -1178815672.00
           time 2 : -1178815672.00
          Frame count is 10
          circles.size = 1
 time in ms  =834,  deadline missed at instant = 10
fps= 2.646941
final jitter calculated = 112
time1 : -1178815672.00
           time 2 : -1178815672.00
          Frame count is 11
          circles.size = 1
 time in ms  =869,  deadline missed at instant = 11
```

Fig :- 24   960*720 Circle



```
          Frame count is 15
          circles.size = 1
 time in ms  =853,  deadline missed at instant = 15
time1 : -1178678672.00
           time 2 : -1178678672.00
          Frame count is 16
          circles.size = 1
 time in ms  =866,  deadline missed at instant = 16
^C
pi@raspberrypi:~/opencv/mybin $ sudo nano raj567890.cpp
pi@raspberrypi:~/opencv/mybin $ g++ `pkg-config opencv --cflags` raj567890.cpp -o raj567890 `pkg-config opencv --libs` -lm -lpthread
pi@raspberrypi:~/opencv/mybin $ ./raj567890
using default
Pthread Policy is SCHED_OTHER
time1 : -1178649672.00
           time 2 : -1178649672.00
          Frame count is 1
          circles.size = 0
time1 : -1178648672.00
           time 2 : -1178648672.00
          Frame count is 2
          circles.size = 0
time1 : -1178647672.00
           time 2 : -1178647672.00
          Frame count is 3
          circles.size = 1
=deadline is not missed at instant 91
time1 : -1178646672.00
           time 2 : -1178646672.00
          Frame count is 4
          circles.size = 1
 time in ms  =862,  deadline missed at instant = 4
time1 : -1178645672.00
           time 2 : -1178645672.00
          Frame count is 5
          circles.size = 1
=deadline is not missed at instant 1
time1 : -1178645672.00
           time 2 : -1178645672.00
          Frame count is 6
          circles.size = 1
 time in ms  =898,  deadline missed at instant = 6
time1 : -1178644672.00
           time 2 : -1178644672.00
          Frame count is 7
          circles.size = 1
 time in ms  =886,  deadline missed at instant = 7
time1 : -1178643672.00
           time 2 : -1178643672.00
          Frame count is 8
          circles.size = 1
 time in ms  =954,  deadline missed at instant = 8
time1 : -1178642672.00
           time 2 : -1178642672.00
          Frame count is 9
          circles.size = 1
 time in ms  =856,  deadline missed at instant = 9
time1 : -1178641672.00
           time 2 : -1178641672.00
          Frame count is 10
          circles.size = 1
 time in ms  =848,  deadline missed at instant = 10
fps= 2.158151
final jitter calculated = 41
time1 : -1178640672.00
           time 2 : -1178640672.00
          Frame count is 11
          circles.size = 1
 time in ms  =863,  deadline missed at instant = 11
time1 : -1178639672.00
           time 2 : -1178639672.00
          Frame count is 12
```

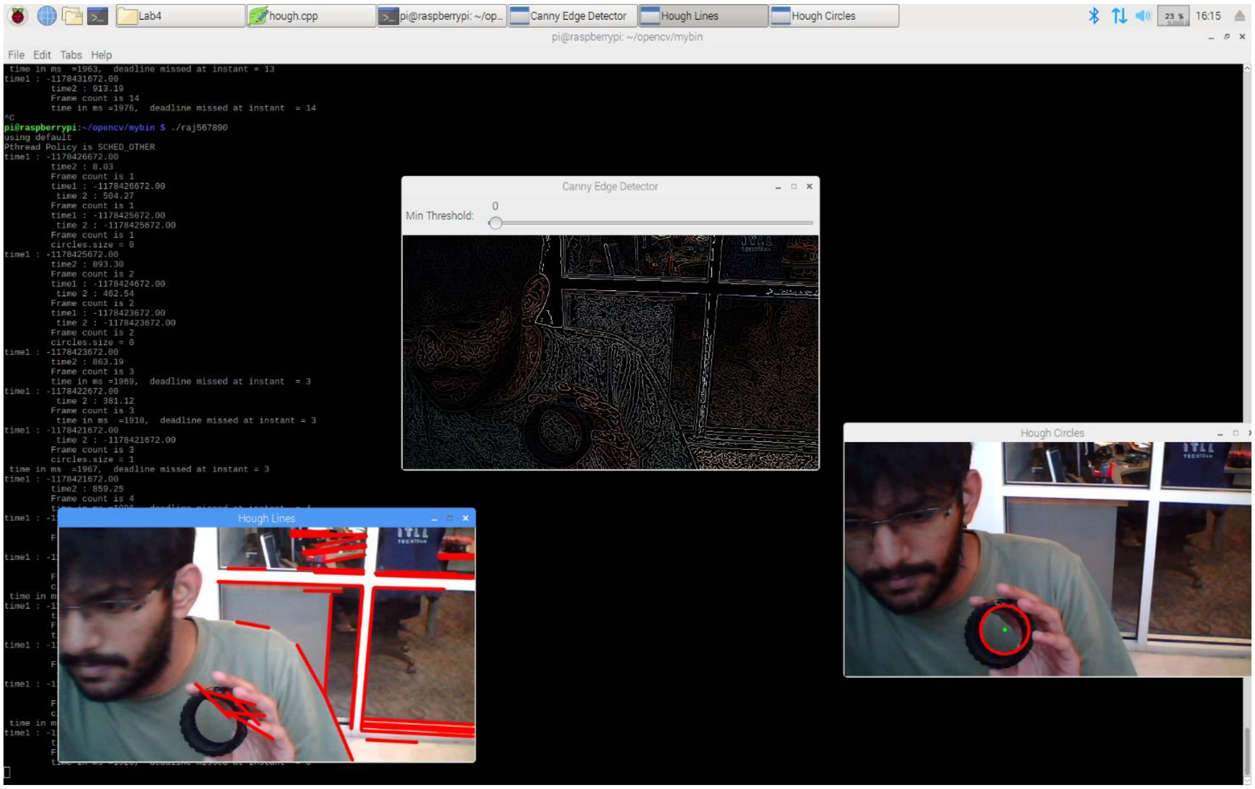
Fig :- 25 640*480 Circle



```
         circles.size = 0
=deadline is not missed at instant 162
time1 : -1178582672.00
          time 2 : -1178582672.00
         Frame count is 4
         circles.size = 0
=deadline is not missed at instant 138
time1 : -1178581672.00
          time 2 : -1178581672.00
         Frame count is 5
         circles.size = 0
=deadline is not missed at instant 147
time1 : -1178581672.00
          time 2 : -1178581672.00
         Frame count is 6
         circles.size = 0
=deadline is not missed at instant 140
time1 : -1178580672.00
          time 2 : -1178580672.00
         Frame count is 7
         circles.size = 0
=deadline is not missed at instant 172
time1 : -1178579672.00
          time 2 : -1178579672.00
         Frame count is 8
         circles.size = 0
=deadline is not missed at instant 143
time1 : -1178579672.00
          time 2 : -1178579672.00
         Frame count is 9
         circles.size = 0
=deadline is not missed at instant 122
time1 : -1178578672.00
          time 2 : -1178578672.00
         Frame count is 10
         circles.size = 0
=deadline is not missed at instant 161
fps= 1.981945
final jitter calculated = 118
time1 : -1178577672.00
          time 2 : -1178577672.00
         Frame count is 11
         circles.size = 1
=deadline is not missed at instant 84
time1 : -1178576672.00
          time 2 : -1178576672.00
         Frame count is 12
         circles.size = 1
=deadline is not missed at instant 132
time1 : -1178576672.00
          time 2 : -1178576672.00
         Frame count is 13
         circles.size = 1
=deadline is not missed at instant 136
time1 : -1178575672.00
          time 2 : -1178575672.00
         Frame count is 14
         circles.size = 1
=deadline is not missed at instant 94
time1 : -1178574672.00
          time 2 : -1178574672.00
         Frame count is 15
         circles.size = 1
=deadline is not missed at instant 140
time1 : -1178574672.00
          time 2 : -1178574672.00
         Frame count is 16
         circles.size = 1
=deadline is not missed at instant 112
time1 : -1178573672.00
          time 2 : -1178573672.00
         Frame count is 17
```

Fig:- 26 320*240 Circle

Final Screenshot of combined 3 Codes



```
 time in ms  =1963,  deadline missed at instant = 13
time1 : -1178431672.00
         time2 : 913.19
         Frame count is 14
         time in ms =1976,  deadline missed at instant  = 14
^C
pi@raspberrypi:~/opencv/mybin $ ./raj567890
using default
Pthread Policy is SCHED_OTHER
time1 : -1178426672.00
         time2 : 8.03
         Frame count is 1
         time1 : -1178426672.00
          time 2 : 504.27
         Frame count is 1
         time1 : -1178425672.00
          time 2 : -1178425672.00
         Frame count is 1
         circles.size = 0
time1 : -1178425672.00
         time2 : 893.30
         Frame count is 2
         time1 : -1178424672.00
          time 2 : 462.54
         Frame count is 2
         time1 : -1178423672.00
          time 2 : -1178423672.00
         Frame count is 2
         circles.size = 0
time1 : -1178423672.00
         time2 : 863.19
         Frame count is 3
         time in ms =1969,  deadline missed at instant  = 3
time1 : -1178422672.00
          time 2 : 381.12
         Frame count is 3
          time in ms  =1918,  deadline missed at instant = 3
time1 : -1178421672.00
          time 2 : -1178421672.00
         Frame count is 3
         circles.size = 1
 time in ms  =1967,  deadline missed at instant = 3
time1 : -1178421672.00
         time2 : 859.25
         Frame count is 4
```

Fig 27 :- Combined 3 codes into 1 , (Semaphores Used)

References :-

1) Q-3 - http://mercury.pr.erau.edu/~siewerts/cs415/code/computer-vision/simpler-capture/
   Link for Simple capture code given by Professor Sam Siewert

2) https://en.wikipedia.org/wiki/Canny_edge_detector

3) Three codes are taken from following link of Professor Sam Siewert
   http://mercury.pr.erau.edu/~siewerts/cs415/code/computer_vision_cv3_tested/
   - Simple Canny Interactive
   - Simple Hough Elliptical
   - Simple Hough interactive