University of Colorado
Boulder

EXERCISE 1

BY

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UNDER THE GUIDANCE OF:

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UNIVERSITY OF COLORADO BOULDER

6/21/2019

BOARD USED: NVIDIA JETSON NANO

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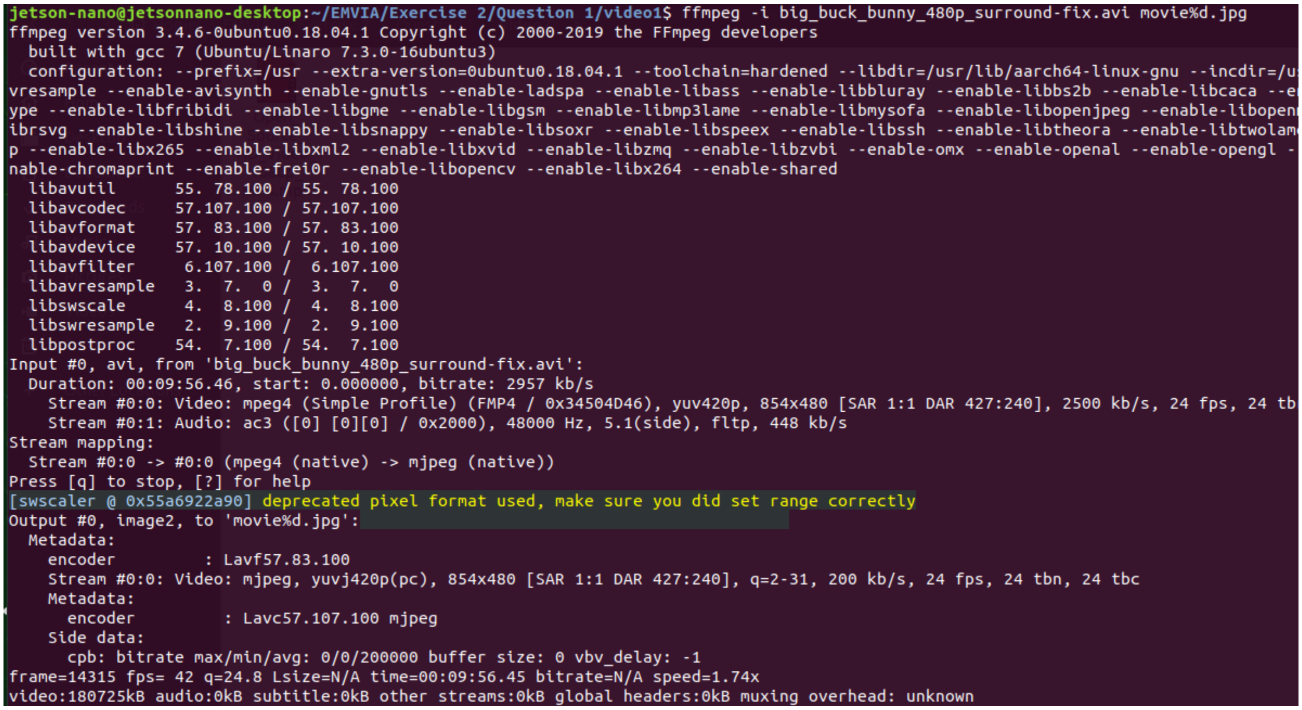
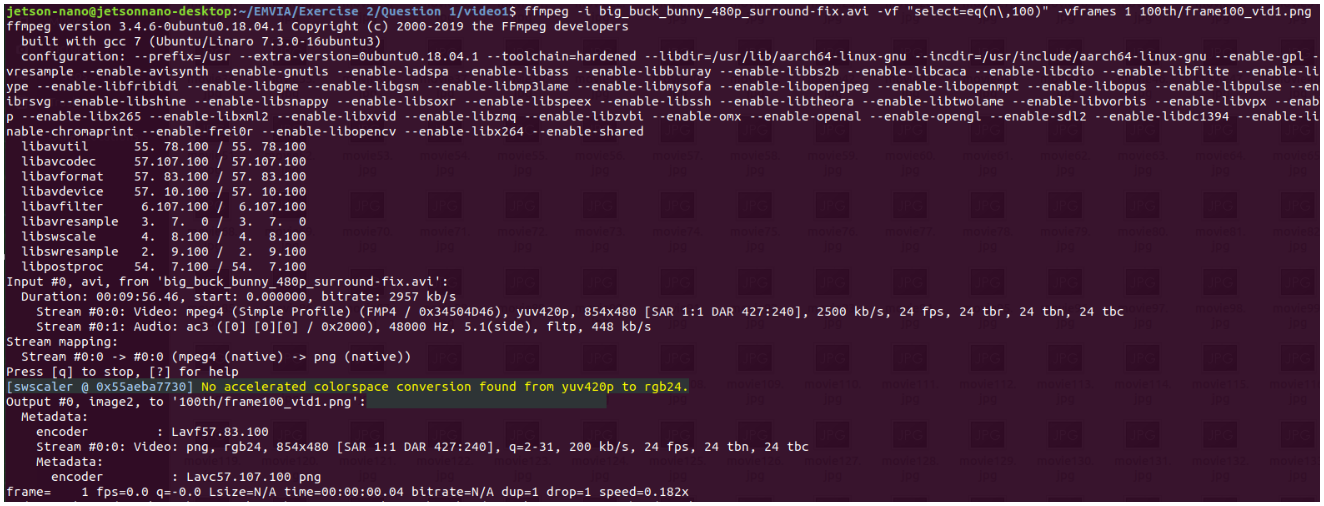
QUESTION 1

BUNNY VIDEO SCREENSHOTS

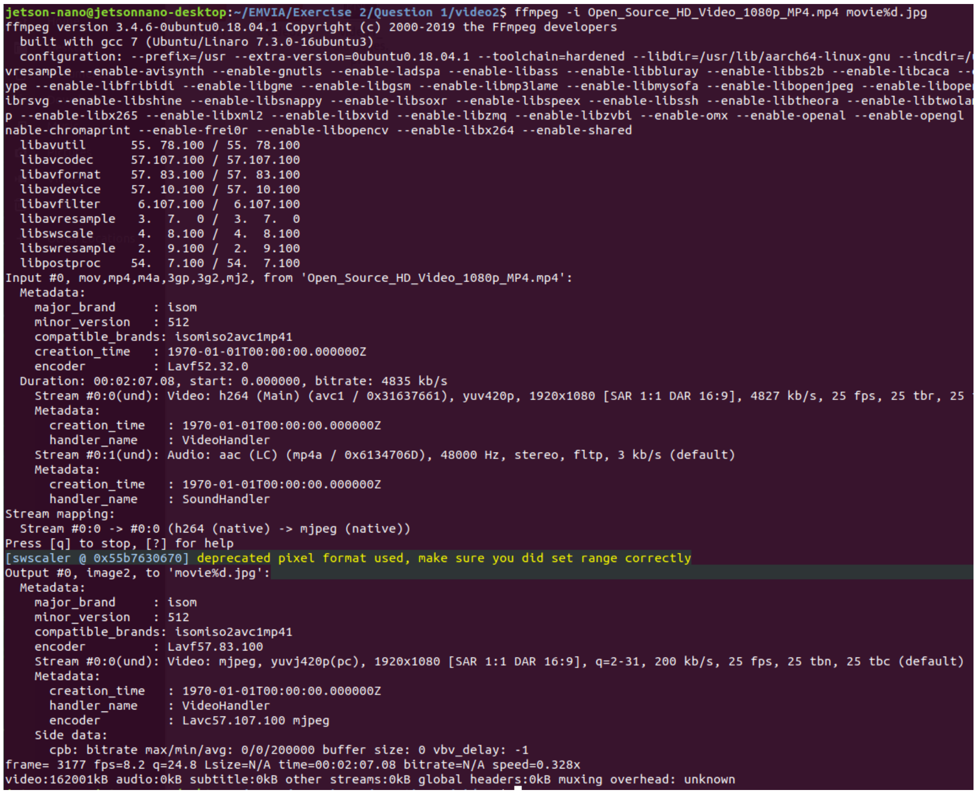


```
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 1/video1$ ffmpeg -i big_buck_bunny_480p_surround-fix.avi movie%d.jpg
ffmpeg version 3.4.6-0ubuntu0.18.04.1 Copyright (c) 2000-2019 the FFmpeg developers
  built with gcc 7 (Ubuntu/Linaro 7.3.0-16ubuntu3)
  configuration: --prefix=/usr --extra-version=0ubuntu0.18.04.1 --toolchain=hardened --libdir=/usr/lib/aarch64-linux-gnu --incdir=/u
vresample --enable-avisynth --enable-gnutls --enable-ladspa --enable-libass --enable-libbluray --enable-libbs2b --enable-libcaca --e
ype --enable-libfribidi --enable-libgme --enable-libgsm --enable-libmp3lame --enable-libmysofa --enable-libopenjpeg --enable-libopen
ibrsvg --enable-libshine --enable-libsnappy --enable-libsoxr --enable-libspeex --enable-libssh --enable-libtheora --enable-libtwolam
p --enable-libx265 --enable-libxml2 --enable-libxvid --enable-libzmq --enable-libzvbi --enable-omx --enable-openal --enable-opengl -
nable-chromaprint --enable-frei0r --enable-libopencv --enable-libx264 --enable-shared
  libavutil      55. 78.100 / 55. 78.100
  libavcodec     57.107.100 / 57.107.100
  libavformat    57. 83.100 / 57. 83.100
  libavdevice    57. 10.100 / 57. 10.100
  libavfilter     6.107.100 /  6.107.100
  libavresample   3.  7.  0 /  3.  7.  0
  libswscale      4.  8.100 /  4.  8.100
  libswresample   2.  9.100 /  2.  9.100
  libpostproc    54.  7.100 / 54.  7.100
Input #0, avi, from 'big_buck_bunny_480p_surround-fix.avi':
  Duration: 00:09:56.46, start: 0.000000, bitrate: 2957 kb/s
    Stream #0:0: Video: mpeg4 (Simple Profile) (FMP4 / 0x34504D46), yuv420p, 854x480 [SAR 1:1 DAR 427:240], 2500 kb/s, 24 fps, 24 tb
    Stream #0:1: Audio: ac3 ([0] [0][0] / 0x2000), 48000 Hz, 5.1(side), fltp, 448 kb/s
Stream mapping:
  Stream #0:0 -> #0:0 (mpeg4 (native) -> mjpeg (native))
Press [q] to stop, [?] for help
[swscaler @ 0x55a6922a90] deprecated pixel format used, make sure you did set range correctly
Output #0, image2, to 'movie%d.jpg':
  Metadata:
    encoder         : Lavf57.83.100
    Stream #0:0: Video: mjpeg, yuvj420p(pc), 854x480 [SAR 1:1 DAR 427:240], q=2-31, 200 kb/s, 24 fps, 24 tbn, 24 tbc
    Metadata:
      encoder         : Lavc57.107.100 mjpeg
    Side data:
      cpb: bitrate max/min/avg: 0/0/200000 buffer size: 0 vbv_delay: -1
frame=14315 fps= 42 q=24.8 Lsize=N/A time=00:09:56.45 bitrate=N/A speed=1.74x
video:180725kB audio:0kB subtitle:0kB other streams:0kB global headers:0kB muxing overhead: unknown
```

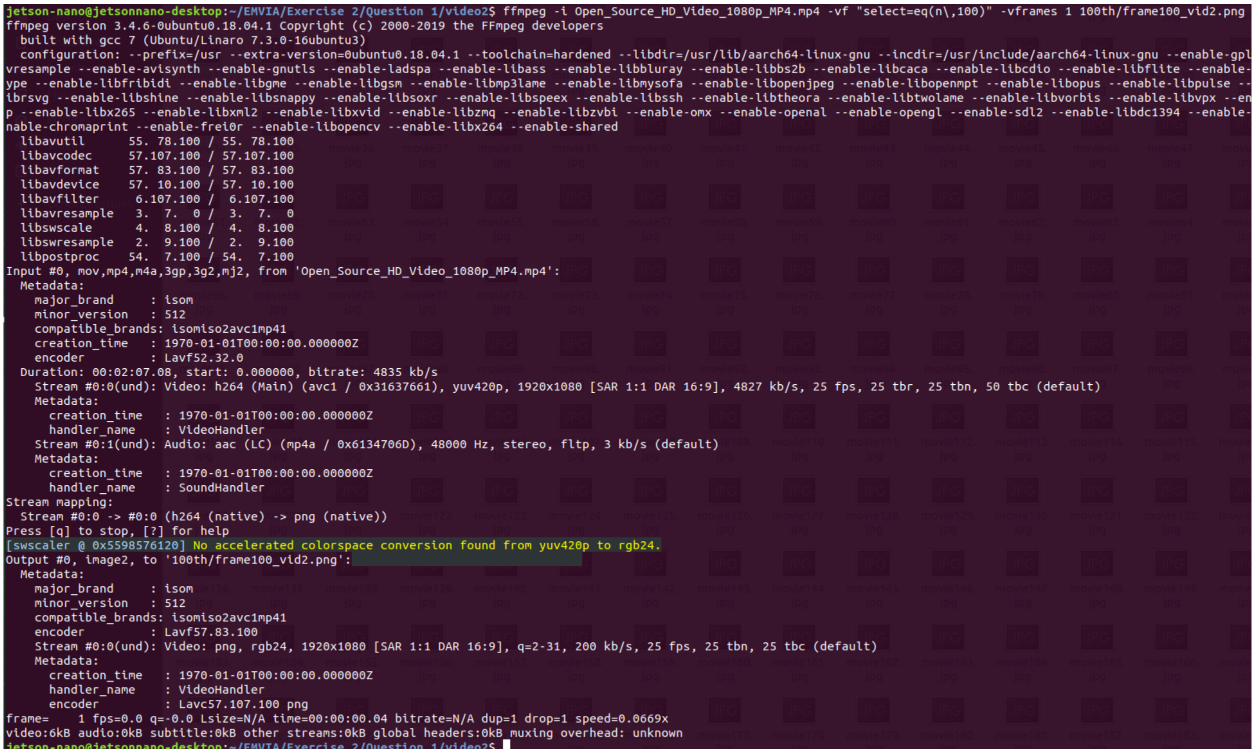


```
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 1/video1$ ffmpeg -i big_buck_bunny_480p_surround-fix.avi -vf "select=eq(n\,100)" -vframes 1 100th/frame100_vid1.png
ffmpeg version 3.4.6-0ubuntu0.18.04.1 Copyright (c) 2000-2019 the FFmpeg developers
  built with gcc 7 (Ubuntu/Linaro 7.3.0-16ubuntu3)
  configuration: --prefix=/usr --extra-version=0ubuntu0.18.04.1 --toolchain=hardened --libdir=/usr/lib/aarch64-linux-gnu --incdir=/usr/include/aarch64-linux-gnu --enable-gpl -
vresample --enable-avisynth --enable-gnutls --enable-ladspa --enable-libass --enable-libbluray --enable-libbs2b --enable-libcaca --enable-libcdio --enable-libflite --enable-li
ype --enable-libfribidi --enable-libgme --enable-libgsm --enable-libmp3lame --enable-libmysofa --enable-libopenjpeg --enable-libopenmpt --enable-libopus --enable-libpulse --en
ibrsvg --enable-libshine --enable-libsnappy --enable-libsoxr --enable-libspeex --enable-libssh --enable-libtheora --enable-libtwolame --enable-libvorbis --enable-libvpx --enab
p --enable-libx265 --enable-libxml2 --enable-libxvid --enable-libzmq --enable-libzvbi --enable-omx --enable-openal --enable-opengl --enable-sdl2 --enable-libdc1394 --enable-li
nable-chromaprint --enable-frei0r --enable-libopencv --enable-libx264 --enable-shared
  libavutil      55. 78.100 / 55. 78.100
  libavcodec     57.107.100 / 57.107.100
  libavformat    57. 83.100 / 57. 83.100
  libavdevice    57. 10.100 / 57. 10.100
  libavfilter     6.107.100 /  6.107.100
  libavresample   3.  7.  0 /  3.  7.  0
  libswscale      4.  8.100 /  4.  8.100
  libswresample   2.  9.100 /  2.  9.100
  libpostproc    54.  7.100 / 54.  7.100
Input #0, avi, from 'big_buck_bunny_480p_surround-fix.avi':
  Duration: 00:09:56.46, start: 0.000000, bitrate: 2957 kb/s
    Stream #0:0: Video: mpeg4 (Simple Profile) (FMP4 / 0x34504D46), yuv420p, 854x480 [SAR 1:1 DAR 427:240], 2500 kb/s, 24 fps, 24 tbr, 24 tbn, 24 tbc
    Stream #0:1: Audio: ac3 ([0] [0][0] / 0x2000), 48000 Hz, 5.1(side), fltp, 448 kb/s
Stream mapping:
  Stream #0:0 -> #0:0 (mpeg4 (native) -> png (native))
Press [q] to stop, [?] for help
[swscaler @ 0x55aeba7730] No accelerated colorspace conversion found from yuv420p to rgb24.
Output #0, image2, to '100th/frame100_vid1.png':
  Metadata:
    encoder         : Lavf57.83.100
    Stream #0:0: Video: png, rgb24, 854x480 [SAR 1:1 DAR 427:240], q=2-31, 200 kb/s, 24 fps, 24 tbn, 24 tbc
    Metadata:
      encoder         : Lavc57.107.100 png
frame=    1 fps=0.0 q=-0.0 Lsize=N/A time=00:00:00.04 bitrate=N/A dup=1 drop=1 speed=0.182x
```

OPEN SOURCE VIDEO SCREENSHOTS



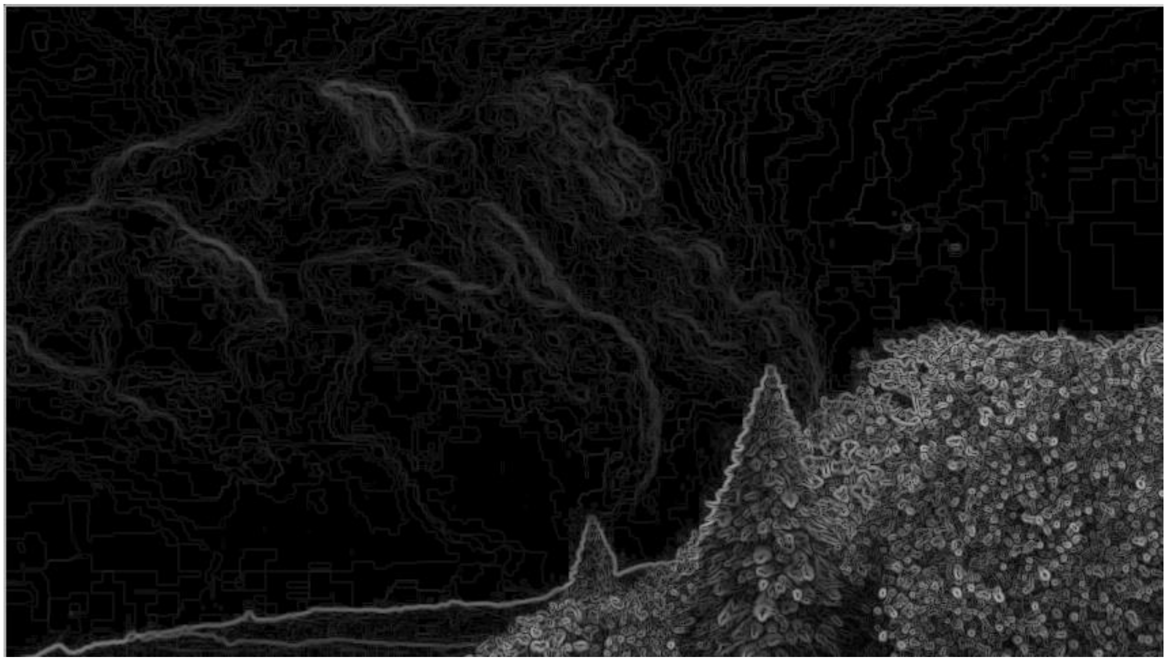
```
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 1/video2$ ffmpeg -i Open_Source_HD_Video_1080p_MP4.mp4 movie%d.jpg
ffmpeg version 3.4.6-0ubuntu0.18.04.1 Copyright (c) 2000-2019 the FFmpeg developers
  built with gcc 7 (Ubuntu/Linaro 7.3.0-16ubuntu3)
  configuration: --prefix=/usr --extra-version=0ubuntu0.18.04.1 --toolchain=hardened --libdir=/usr/lib/aarch64-linux-gnu --incdir=/
vresample --enable-avisynth --enable-gnutls --enable-ladspa --enable-libass --enable-libbluray --enable-libbs2b --enable-libcaca --
ype --enable-libfribidi --enable-libgme --enable-libgsm --enable-libmp3lame --enable-libmysofa --enable-libopenjpeg --enable-libope
ibrsvg --enable-libshine --enable-libsnappy --enable-libsoxr --enable-libspeex --enable-libssh --enable-libtheora --enable-libtwola
p --enable-libx265 --enable-libxml2 --enable-libxvid --enable-libzmq --enable-libzvbi --enable-omx --enable-openal --enable-opengl
nable-chromaprint --enable-frei0r --enable-libopencv --enable-libx264 --enable-shared
  libavutil      55. 78.100 / 55. 78.100
  libavcodec     57.107.100 / 57.107.100
  libavformat    57. 83.100 / 57. 83.100
  libavdevice    57. 10.100 / 57. 10.100
  libavfilter     6.107.100 /  6.107.100
  libavresample   3.  7.  0 /  3.  7.  0
  libswscale      4.  8.100 /  4.  8.100
  libswresample   2.  9.100 /  2.  9.100
  libpostproc    54.  7.100 / 54.  7.100
Input #0, mov,mp4,m4a,3gp,3g2,mj2, from 'Open_Source_HD_Video_1080p_MP4.mp4':
  Metadata:
    major_brand     : isom
    minor_version   : 512
    compatible_brands: isomiso2avc1mp41
    creation_time   : 1970-01-01T00:00:00.000000Z
    encoder         : Lavf52.32.0
  Duration: 00:02:07.08, start: 0.000000, bitrate: 4835 kb/s
    Stream #0:0(und): Video: h264 (Main) (avc1 / 0x31637661), yuv420p, 1920x1080 [SAR 1:1 DAR 16:9], 4827 kb/s, 25 fps, 25 tbr, 25
    Metadata:
      creation_time   : 1970-01-01T00:00:00.000000Z
      handler_name    : VideoHandler
    Stream #0:1(und): Audio: aac (LC) (mp4a / 0x6134706D), 48000 Hz, stereo, fltp, 3 kb/s (default)
    Metadata:
      creation_time   : 1970-01-01T00:00:00.000000Z
      handler_name    : SoundHandler
Stream mapping:
  Stream #0:0 -> #0:0 (h264 (native) -> mjpeg (native))
Press [q] to stop, [?] for help
[swscaler @ 0x55b7630670] deprecated pixel format used, make sure you did set range correctly
Output #0, image2, to 'movie%d.jpg':
  Metadata:
    major_brand     : isom
    minor_version   : 512
    compatible_brands: isomiso2avc1mp41
    encoder         : Lavf57.83.100
    Stream #0:0(und): Video: mjpeg, yuvj420p(pc), 1920x1080 [SAR 1:1 DAR 16:9], q=2-31, 200 kb/s, 25 fps, 25 tbn, 25 tbc (default)
    Metadata:
      creation_time   : 1970-01-01T00:00:00.000000Z
      handler_name    : VideoHandler
      encoder         : Lavc57.107.100 mjpeg
    Side data:
      cpb: bitrate max/min/avg: 0/0/200000 buffer size: 0 vbv_delay: -1
frame= 3177 fps=8.2 q=24.8 Lsize=N/A time=00:02:07.08 bitrate=N/A speed=0.328x
video:162001kB audio:0kB subtitle:0kB other streams:0kB global headers:0kB muxing overhead: unknown
```



```
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 1/video2$ ffmpeg -i Open_Source_HD_Video_1080p_MP4.mp4 -vf "select=eq(n\,100)" -vframes 1 100th/frame100_vid2.png
ffmpeg version 3.4.6-0ubuntu0.18.04.1 Copyright (c) 2000-2019 the FFmpeg developers
  built with gcc 7 (Ubuntu/Linaro 7.3.0-16ubuntu3)
  configuration: --prefix=/usr --extra-version=0ubuntu0.18.04.1 --toolchain=hardened --libdir=/usr/lib/aarch64-linux-gnu --incdir=/usr/include/aarch64-linux-gnu --enable-gpl
vresample --enable-avisynth --enable-gnutls --enable-ladspa --enable-libass --enable-libbluray --enable-libbs2b --enable-libcaca --enable-libcdio --enable-libflite --enable-
ype --enable-libfribidi --enable-libgme --enable-libgsm --enable-libmp3lame --enable-libmysofa --enable-libopenjpeg --enable-libopenmpt --enable-libopus --enable-libpulse --
ibrsvg --enable-libshine --enable-libsnappy --enable-libsoxr --enable-libspeex --enable-libssh --enable-libtheora --enable-libtwolame --enable-libvorbis --enable-libvpx --en
p --enable-libx265 --enable-libxml2 --enable-libxvid --enable-libzmq --enable-libzvbi --enable-omx --enable-openal --enable-opengl --enable-sdl2 --enable-libdc1394 --enable-
nable-chromaprint --enable-frei0r --enable-libopencv --enable-libx264 --enable-shared
  libavutil      55. 78.100 / 55. 78.100
  libavcodec     57.107.100 / 57.107.100
  libavformat    57. 83.100 / 57. 83.100
  libavdevice    57. 10.100 / 57. 10.100
  libavfilter     6.107.100 /  6.107.100
  libavresample   3.  7.  0 /  3.  7.  0
  libswscale      4.  8.100 /  4.  8.100
  libswresample   2.  9.100 /  2.  9.100
  libpostproc    54.  7.100 / 54.  7.100
Input #0, mov,mp4,m4a,3gp,3g2,mj2, from 'Open_Source_HD_Video_1080p_MP4.mp4':
  Metadata:
    major_brand     : isom
    minor_version   : 512
    compatible_brands: isomiso2avc1mp41
    creation_time   : 1970-01-01T00:00:00.000000Z
    encoder         : Lavf52.32.0
  Duration: 00:02:07.08, start: 0.000000, bitrate: 4835 kb/s
    Stream #0:0(und): Video: h264 (Main) (avc1 / 0x31637661), yuv420p, 1920x1080 [SAR 1:1 DAR 16:9], 4827 kb/s, 25 fps, 25 tbr, 25 tbn, 50 tbc (default)
    Metadata:
      creation_time   : 1970-01-01T00:00:00.000000Z
      handler_name    : VideoHandler
    Stream #0:1(und): Audio: aac (LC) (mp4a / 0x6134706D), 48000 Hz, stereo, fltp, 3 kb/s (default)
    Metadata:
      creation_time   : 1970-01-01T00:00:00.000000Z
      handler_name    : SoundHandler
Stream mapping:
  Stream #0:0 -> #0:0 (h264 (native) -> png (native))
Press [q] to stop, [?] for help
[swscaler @ 0x5598576120] No accelerated colorspace conversion found from yuv420p to rgb24.
Output #0, image2, to '100th/frame100_vid2.png':
  Metadata:
    major_brand     : isom
    minor_version   : 512
    compatible_brands: isomiso2avc1mp41
    encoder         : Lavf57.83.100
    Stream #0:0(und): Video: png, rgb24, 1920x1080 [SAR 1:1 DAR 16:9], q=2-31, 200 kb/s, 25 fps, 25 tbn, 25 tbc (default)
    Metadata:
      creation_time   : 1970-01-01T00:00:00.000000Z
      handler_name    : VideoHandler
      encoder         : Lavc57.107.100 png
frame=    1 fps=0.0 q=-0.0 Lsize=N/A time=00:00:00.04 bitrate=N/A dup=1 drop=1 speed=0.0669x
video:6kB audio:0kB subtitle:0kB other streams:0kB global headers:0kB muxing overhead: unknown
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 1/video2$
```

QUESTION 2

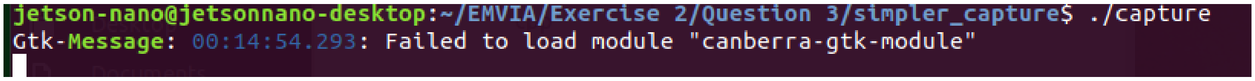
SOBEL SCREENSHOT OF 100TH FRAME OF BUNNY AND OPEN SOURCE VIDEO



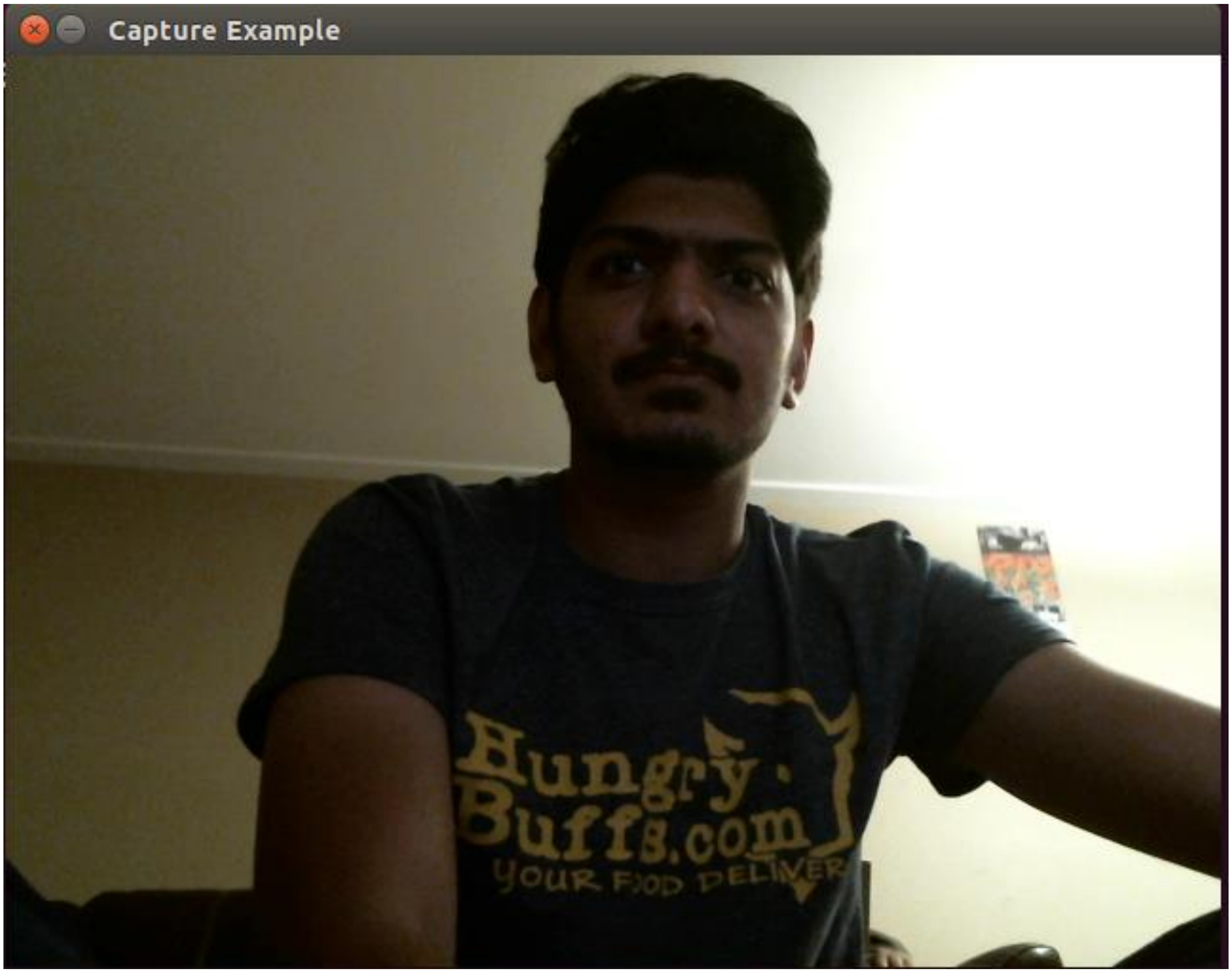
Both the Images were converted to grayscale mode to obtain black and white images. The Image was converted by right clicking the image to find the grayscale mode under mode in image section. Then Sobel Operator was applied available in the tools menu to obtain the above Images.

QUESTION 3

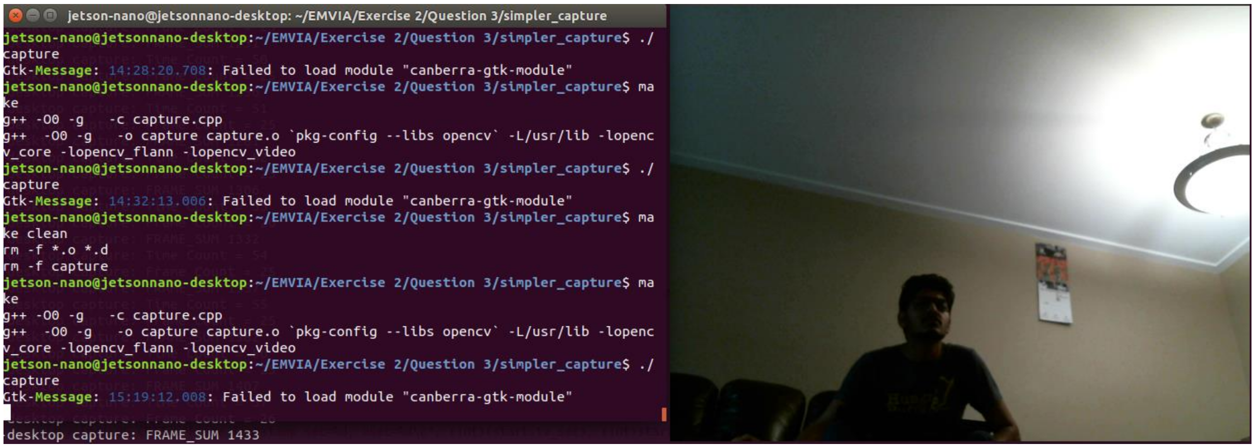
SCREENSHOTS OF SIMPLER CAPTURE WITHOUT MODIFYING CODE



```
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 3/simpler_capture$ ./capture
Gtk-Message: 00:14:54.293: Failed to load module "canberra-gtk-module"
```



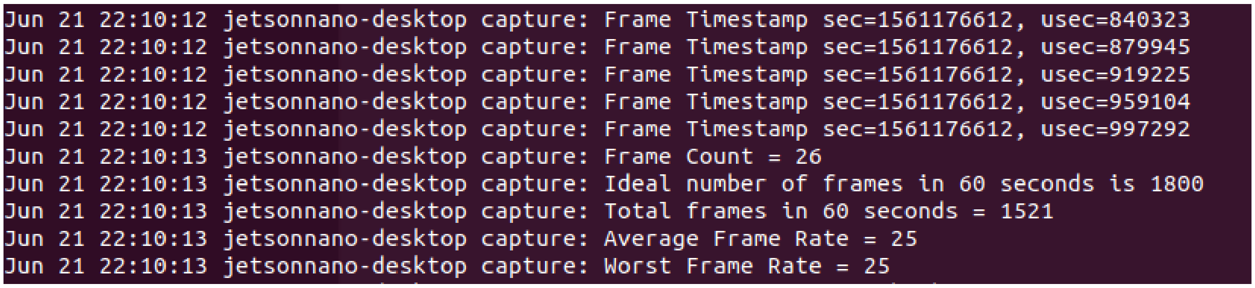
SCREENSHOTS OF SIMPLER CAPTURE OF MODIFIED CODE



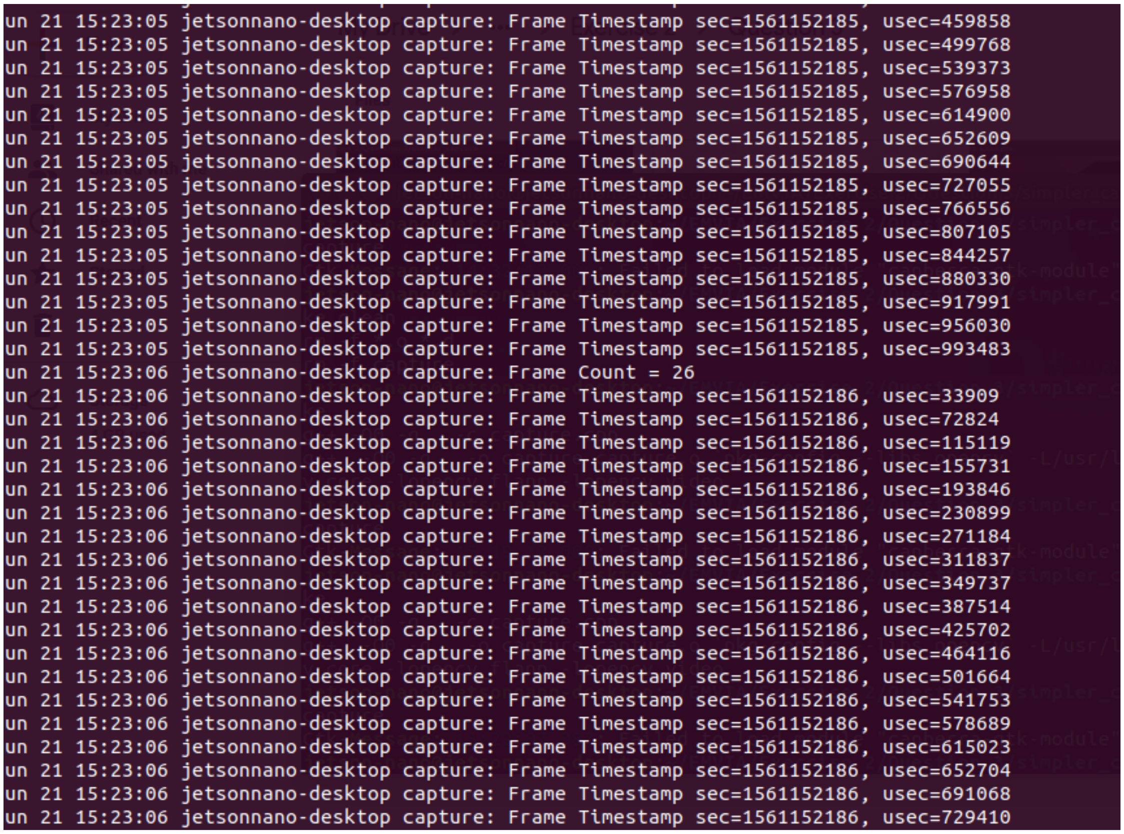
jetson-nano@jetsonnano-desktop: ~/EMVIA/Exercise 2/Question 3/simpler_capture

```
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 3/simpler_capture$ ./
capture
Gtk-Message: 14:28:20.708: Failed to load module "canberra-gtk-module"
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 3/simpler_capture$ ma
ke
g++ -O0 -g   -c capture.cpp
g++  -O0 -g   -o capture capture.o `pkg-config --libs opencv` -L/usr/lib -lopenc
v_core -lopencv_flann -lopencv_video
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 3/simpler_capture$ ./
capture
Gtk-Message: 14:32:13.006: Failed to load module "canberra-gtk-module"
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 3/simpler_capture$ ma
ke clean
rm -f *.o *.d
rm -f capture
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 3/simpler_capture$ ma
ke
g++ -O0 -g   -c capture.cpp
g++  -O0 -g   -o capture capture.o `pkg-config --libs opencv` -L/usr/lib -lopenc
v_core -lopencv_flann -lopencv_video
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 3/simpler_capture$ ./
capture
Gtk-Message: 15:19:12.008: Failed to load module "canberra-gtk-module"

-desktop capture: FRAME_SUM 1433
```



```
Jun 21 22:10:12 jetsonnano-desktop capture: Frame Timestamp sec=1561176612, usec=840323
Jun 21 22:10:12 jetsonnano-desktop capture: Frame Timestamp sec=1561176612, usec=879945
Jun 21 22:10:12 jetsonnano-desktop capture: Frame Timestamp sec=1561176612, usec=919225
Jun 21 22:10:12 jetsonnano-desktop capture: Frame Timestamp sec=1561176612, usec=959104
Jun 21 22:10:12 jetsonnano-desktop capture: Frame Timestamp sec=1561176612, usec=997292
Jun 21 22:10:13 jetsonnano-desktop capture: Frame Count = 26
Jun 21 22:10:13 jetsonnano-desktop capture: Ideal number of frames in 60 seconds is 1800
Jun 21 22:10:13 jetsonnano-desktop capture: Total frames in 60 seconds = 1521
Jun 21 22:10:13 jetsonnano-desktop capture: Average Frame Rate = 25
Jun 21 22:10:13 jetsonnano-desktop capture: Worst Frame Rate = 25
```



```
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=459858
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=499768
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=539373
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=576958
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=614900
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=652609
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=690644
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=727055
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=766556
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=807105
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=844257
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=880330
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=917991
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=956030
un 21 15:23:05 jetsonnano-desktop capture: Frame Timestamp sec=1561152185, usec=993483
un 21 15:23:06 jetsonnano-desktop capture: Frame Count = 26
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=33909
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=72824
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=115119
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=155731
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=193846
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=230899
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=271184
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=311837
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=349737
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=387514
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=425702
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=464116
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=501664
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=541753
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=578689
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=615023
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=652704
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=691068
un 21 15:23:06 jetsonnano-desktop capture: Frame Timestamp sec=1561152186, usec=729410
```

SIMPLER CAPTURE CODE DESCRIPTION

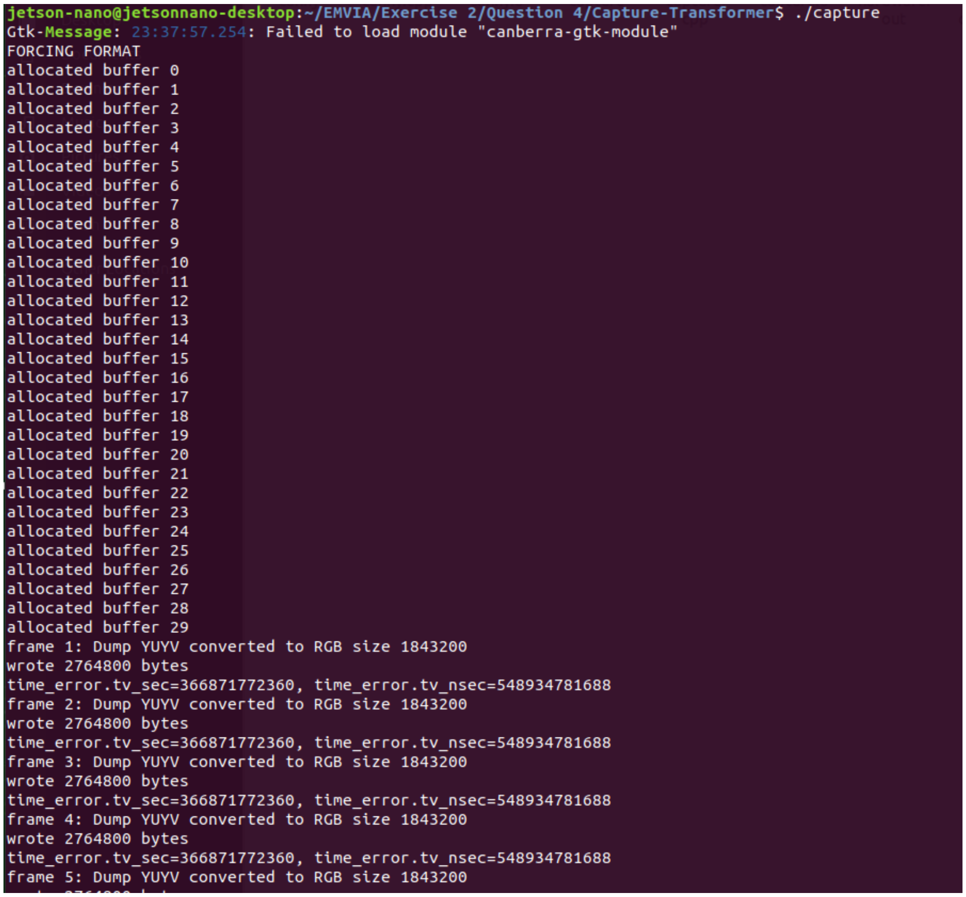
The code has been modified to analyze average frame rate, worst frame rate and jitter over a period of 60 seconds. The code keeps a tab on the number of frames every second by maintaining a count of the number of frames captured by the camera. The total number of frames is calculated over 60 seconds to get the average frame rate. Average frame rate is obtained by dividing total frames by 60. An algorithm is formulated to update a variable every second to record the least frame rate. Ideally the camera has an fps of 30. So the total frames obtained in 60 seconds should be 1800. Jitter is calculated by calculating the total number of frames recorded in 60 seconds and subtracting it from 1800. The value obtained is then multiplied by 1/30 to obtain jitter.

ANALYSIS

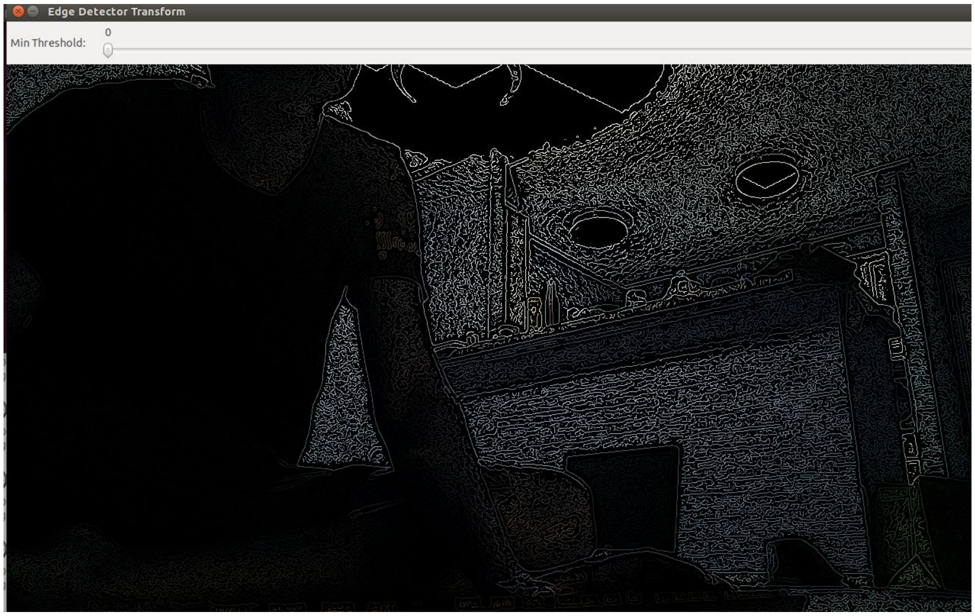
The average frame rate obtained is around 25, the worst frame rate obtained here is 25 and the jitter is 80333333 microseconds. This means that the frame rate obtained was a constant 25 for 60 seconds. The jitter can be speculated because of the kernel being busy in some other task and could not capture all the 30 frames in a second. Some other factors such as I/O latency, context switching can also contribute to jitter as well.

QUESTION 4

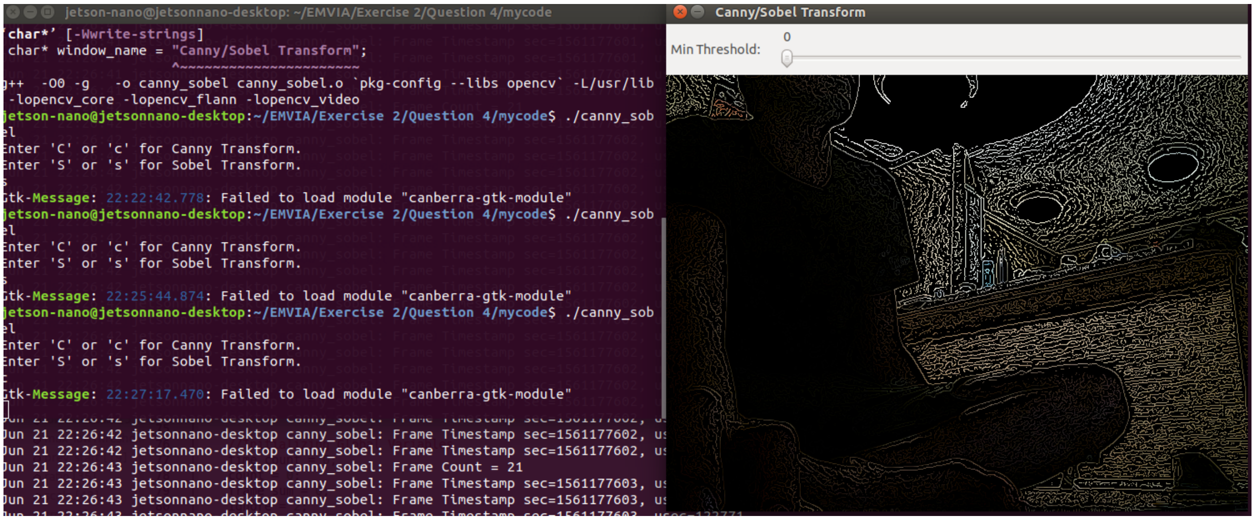
CAPTURE SCREENSHOTS



```
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 4/Capture-Transformer$ ./capture
Gtk-Message: 23:37:57.254: Failed to load module "canberra-gtk-module"
FORCING FORMAT
allocated buffer 0
allocated buffer 1
allocated buffer 2
allocated buffer 3
allocated buffer 4
allocated buffer 5
allocated buffer 6
allocated buffer 7
allocated buffer 8
allocated buffer 9
allocated buffer 10
allocated buffer 11
allocated buffer 12
allocated buffer 13
allocated buffer 14
allocated buffer 15
allocated buffer 16
allocated buffer 17
allocated buffer 18
allocated buffer 19
allocated buffer 20
allocated buffer 21
allocated buffer 22
allocated buffer 23
allocated buffer 24
allocated buffer 25
allocated buffer 26
allocated buffer 27
allocated buffer 28
allocated buffer 29
frame 1: Dump YUYV converted to RGB size 1843200
wrote 2764800 bytes
time_error.tv_sec=366871772360, time_error.tv_nsec=548934781688
frame 2: Dump YUYV converted to RGB size 1843200
wrote 2764800 bytes
time_error.tv_sec=366871772360, time_error.tv_nsec=548934781688
frame 3: Dump YUYV converted to RGB size 1843200
wrote 2764800 bytes
time_error.tv_sec=366871772360, time_error.tv_nsec=548934781688
frame 4: Dump YUYV converted to RGB size 1843200
wrote 2764800 bytes
time_error.tv_sec=366871772360, time_error.tv_nsec=548934781688
frame 5: Dump YUYV converted to RGB size 1843200
```

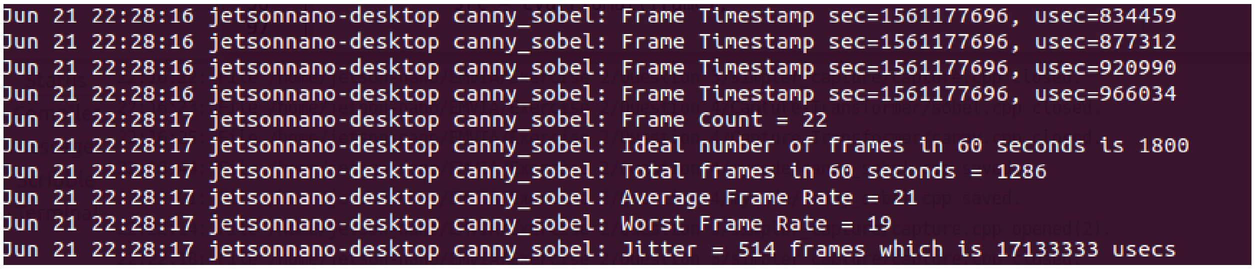


CANNY SCREENSHOTS

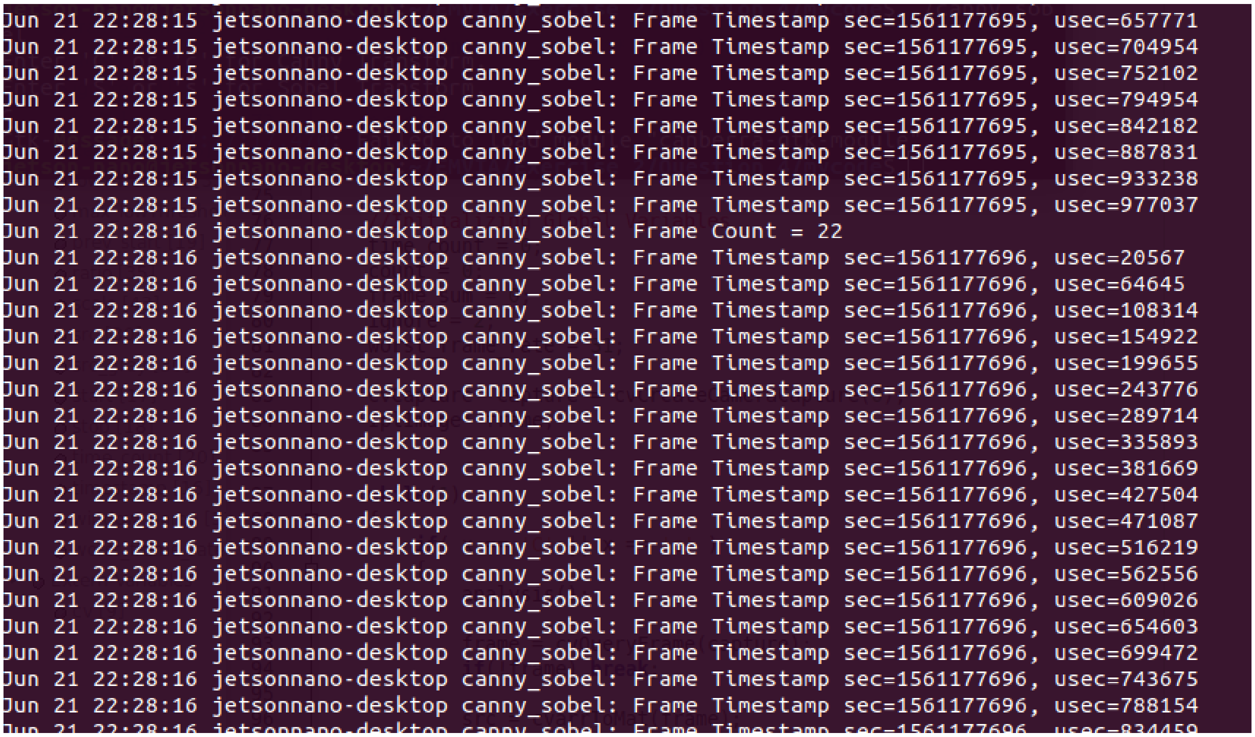

jetson-nano@jetsonnano-desktop: ~/EMVIA/Exercise 2/Question 4/mycode
Canny/Sobel Transform
Min Threshold:
0

```
'char*' [-Wwrite-strings]
 char* window_name = "Canny/Sobel Transform";
                     ^~~~~~~~~~~~~~~~~~~~~~~
g++  -O0 -g   -o canny_sobel canny_sobel.o `pkg-config --libs opencv` -L/usr/lib
 -lopencv_core -lopencv_flann -lopencv_video
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 4/mycode$ ./canny_sob
el
Enter 'C' or 'c' for Canny Transform.
Enter 'S' or 's' for Sobel Transform.
s
Gtk-Message: 22:22:42.778: Failed to load module "canberra-gtk-module"
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 4/mycode$ ./canny_sob
el
Enter 'C' or 'c' for Canny Transform.
Enter 'S' or 's' for Sobel Transform.
s
Gtk-Message: 22:25:44.874: Failed to load module "canberra-gtk-module"
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 4/mycode$ ./canny_sob
el
Enter 'C' or 'c' for Canny Transform.
Enter 'S' or 's' for Sobel Transform.
c
Gtk-Message: 22:27:17.470: Failed to load module "canberra-gtk-module"

Jun 21 22:26:42 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177602, us
Jun 21 22:26:42 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177602, us
Jun 21 22:26:43 jetsonnano-desktop canny_sobel: Frame Count = 21
Jun 21 22:26:43 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177603, us
Jun 21 22:26:43 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177603, us
```

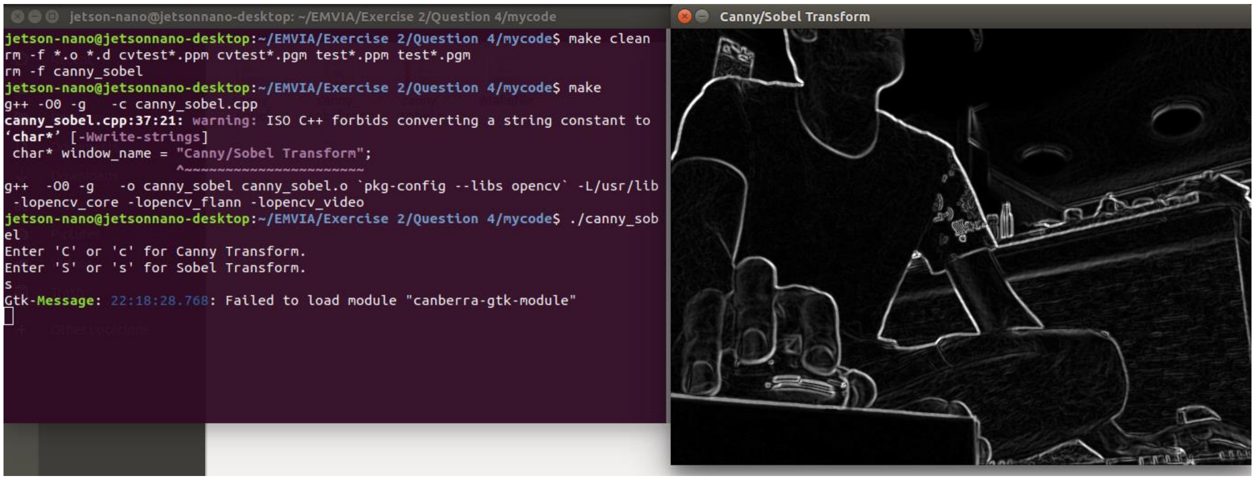


```
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=834459
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=877312
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=920990
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=966034
Jun 21 22:28:17 jetsonnano-desktop canny_sobel: Frame Count = 22
Jun 21 22:28:17 jetsonnano-desktop canny_sobel: Ideal number of frames in 60 seconds is 1800
Jun 21 22:28:17 jetsonnano-desktop canny_sobel: Total frames in 60 seconds = 1286
Jun 21 22:28:17 jetsonnano-desktop canny_sobel: Average Frame Rate = 21
Jun 21 22:28:17 jetsonnano-desktop canny_sobel: Worst Frame Rate = 19
Jun 21 22:28:17 jetsonnano-desktop canny_sobel: Jitter = 514 frames which is 17133333 usecs
```

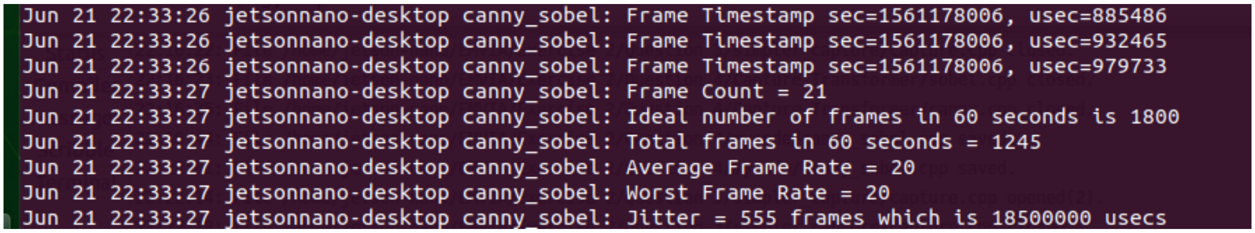


```
Jun 21 22:28:15 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177695, usec=657771
Jun 21 22:28:15 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177695, usec=704954
Jun 21 22:28:15 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177695, usec=752102
Jun 21 22:28:15 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177695, usec=794954
Jun 21 22:28:15 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177695, usec=842182
Jun 21 22:28:15 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177695, usec=887831
Jun 21 22:28:15 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177695, usec=933238
Jun 21 22:28:15 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177695, usec=977037
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Count = 22
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=20567
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=64645
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=108314
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=154922
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=199655
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=243776
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=289714
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=335893
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=381669
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=427504
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=471087
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=516219
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=562556
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=609026
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=654603
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=699472
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=743675
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=788154
Jun 21 22:28:16 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177696, usec=834459
```

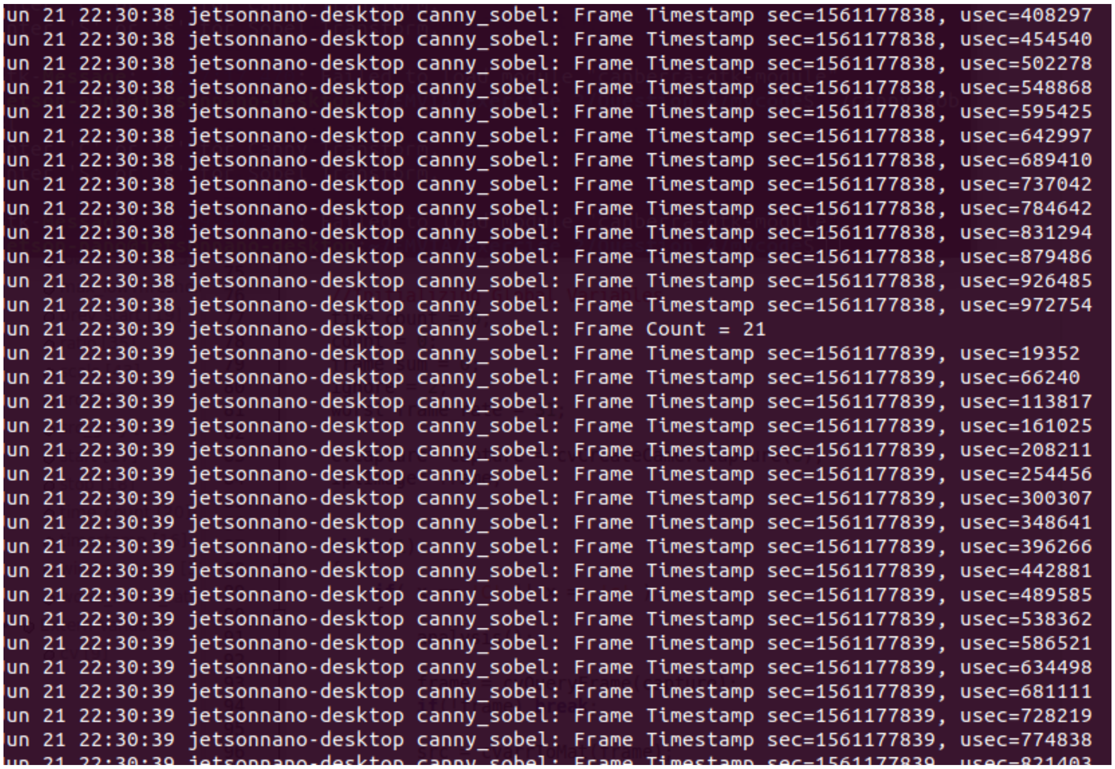
SOBEL SCREENSHOTS


jetson-nano@jetsonnano-desktop: ~/EMVIA/Exercise 2/Question 4/mycode
Canny/Sobel Transform

```
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 4/mycode$ make clean
rm -f *.o *.d cvtest*.ppm cvtest*.pgm test*.ppm test*.pgm
rm -f canny_sobel
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 4/mycode$ make
g++ -O0 -g   -c canny_sobel.cpp
canny_sobel.cpp:37:21: warning: ISO C++ forbids converting a string constant to
'char*' [-Wwrite-strings]
 char* window_name = "Canny/Sobel Transform";
                     ^~~~~~~~~~~~~~~~~~~~~~~
g++  -O0 -g   -o canny_sobel canny_sobel.o `pkg-config --libs opencv` -L/usr/lib
 -lopencv_core -lopencv_flann -lopencv_video
jetson-nano@jetsonnano-desktop:~/EMVIA/Exercise 2/Question 4/mycode$ ./canny_sob
el
Enter 'C' or 'c' for Canny Transform.
Enter 'S' or 's' for Sobel Transform.
s
Gtk-Message: 22:18:28.768: Failed to load module "canberra-gtk-module"
```



```
Jun 21 22:33:26 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561178006, usec=885486
Jun 21 22:33:26 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561178006, usec=932465
Jun 21 22:33:26 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561178006, usec=979733
Jun 21 22:33:27 jetsonnano-desktop canny_sobel: Frame Count = 21
Jun 21 22:33:27 jetsonnano-desktop canny_sobel: Ideal number of frames in 60 seconds is 1800
Jun 21 22:33:27 jetsonnano-desktop canny_sobel: Total frames in 60 seconds = 1245
Jun 21 22:33:27 jetsonnano-desktop canny_sobel: Average Frame Rate = 20
Jun 21 22:33:27 jetsonnano-desktop canny_sobel: Worst Frame Rate = 20
Jun 21 22:33:27 jetsonnano-desktop canny_sobel: Jitter = 555 frames which is 18500000 usecs
```



```
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=408297
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=454540
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=502278
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=548868
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=595425
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=642997
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=689410
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=737042
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=784642
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=831294
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=879486
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=926485
un 21 22:30:38 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177838, usec=972754
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Count = 21
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=19352
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=66240
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=113817
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=161025
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=208211
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=254456
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=300307
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=348641
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=396266
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=442881
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=489585
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=538362
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=586521
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=634498
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=681111
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=728219
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=774838
un 21 22:30:39 jetsonnano-desktop canny_sobel: Frame Timestamp sec=1561177839, usec=821403
```

CODE DESCRIPTION

The code starts with asking the user to enter certain keywords depending on which Sobel and Canny Transforms are applied on the video being captured. The video being captured using cvQueryCapture returns an IplImage* which had to be converted to mat. This was achieved using cvvarrToMat API.

In case of Sobel Transform, gaussianblur API is used to eliminate all the high frequency elements. Then the cvtcolor API is used to convert the image to grayscale. The next step is to obtain gradient in X and Y directions. This is done by using the Sobel function. This function marks the change in pixel intensities for edge detection in X and Y directions. Finally, the X and Y direction gradients are then added to obtain the approximate gradient which gives us the edge detected image.

In case of Canny Transform, the API blur was applied to the frame obtained to reduce the noise in the frame. A 3x3 kernel is applied in order to achieve this. This was followed by the Canny detector function with the required parameters.

ANALYSIS

The average frame rate obtained for canny transform is around 21, the worst frame rate obtained here is 19 and the jitter is 17133333 microseconds.

The average frame rate obtained for canny transform is around 20, the worst frame rate obtained here is 10 and the jitter is 18500000 microseconds.

As you can see the jitter for sobel is more than canny. The reason might be that sobel takes much more time to execute than canny transform.

As you can see, the average frame rate has dipped as compared to that of 3rd question. This might be due to the transform being applied as the frames are being captured. The processor takes much more time for the computation which may result in the frames being missed. The other factors as mentioned in question 3 apply here too which affect the frame rate.

REFERENCES

- https://opencv.org/