Lab 1: Guide on how to configure the Raspberry Pi 400 with a Webcam

Section 1: Raspberry Pi OS Installation & Initial Configuration

MCQs

1. **Which software tool is used to write the Raspberry Pi OS image to a microSD card?**
   A. Etcher
   B. Raspberry Pi Imager
   C. Rufus
   D. Win32 Disk Imager
   Answer: B. Raspberry Pi Imager

2. **When using Raspberry Pi Imager, which setting would you adjust to configure WiFi credentials before booting for the first time?**
   A. Localisation settings
   B. OS Customisation settings
   C. Advanced display settings
   D. Timezone settings
   Answer: B. OS Customisation settings

Short Answer

3. **In the Raspberry Pi Imager's advanced settings, name two items you can configure before flashing the microSD card.**
   Answer:
   - **Hostname of the Raspberry Pi**
   - **Username and password**
   - **WiFi credentials (SSID and password)**
   - **SSH enabling**
   - **Locale settings (timezone, keyboard layout)**

4. **What is the command to update the list of available packages on a Raspberry Pi running Raspberry Pi OS?**
   Answer: sudo apt update

5. **What is the command to upgrade all currently installed packages on a Raspberry Pi?**
   Answer: sudo apt upgrade

Section 2: Hardware Setup & Basic Configuration

MCQs

6. **Which of the following components is not strictly required to get the Raspberry Pi 400 up and running with a webcam?**
   A. MicroSD card with Raspberry Pi OS
   B. Power supply
   C. Ethernet cable
   D. USB webcam
   Answer: C. Ethernet cable (WiFi can be used instead.)

7. **To enable VNC on a headless Raspberry Pi via SSH, which tool do you typically use?**
   A. raspi-config
   B. config.txt
   C. sudo raspi-config
   D. /boot/cmdline.txt
   Answer: C. sudo raspi-config

Short Answer

8. **Which command would you run to edit the network configuration file (dhcpcd.conf) on Raspberry Pi OS?**
   Answer: sudo nano /etc/dhcpcd.conf

9. **Explain why assigning a static IP to your Raspberry Pi can be useful in a lab environment.**
   Answer:
   It ensures the Pi always has the same IP address, making it easier to connect via SSH or VNC without repeatedly looking up the IP.

Section 3: Using SSH and VNC

MCQs

10. **Which of the following protocols is used by VNC to provide a graphical desktop over the network?**
    A. RDP (Remote Desktop Protocol)
    B. RFB (Remote Framebuffer Protocol)
    C. SSH (Secure Shell)
    D. FTP (File Transfer Protocol)
    Answer: B. RFB (Remote Framebuffer Protocol)

Short Answer

11. **What is the default port used by VNC on a Raspberry Pi?**
    Answer: Port 5900

12. **State one way to find your Raspberry Pi's IP address on a local network if you do not have direct access to its desktop.**
    Answer:
    - **Check the device list on your router or mobile hotspot**
    - **Use arp -a on your local machine**
    - **Use a network scanning tool (e.g., nmap)**

Section 4: Webcam Setup & Testing

MCQs

13. **Which command-line tool is typically used to capture a still image on the Raspberry Pi with a USB webcam?**
    A. motion
    B. fswebcam
    C. raspistill
    D. gstreamer
    Answer: B. fswebcam

14. **What is the Linux subsystem or driver model used for webcams on Raspberry Pi OS?**
    A. ALSA
    B. Video4Linux2 (v4l2)
    C. GStreamer
    D. MESA
    Answer: B. Video4Linux2 (v4l2)

Short Answer

15. **Write the exact command to capture a 1280×720 image named image.jpg using fswebcam without displaying the banner text.**
    Answer: fswebcam -r 1280x720 --no-banner image.jpg

16. **Which command is used to list all USB devices connected to the Raspberry Pi?**
    Answer: lsusb

Section 5: Audio Input & arecord

MCQs

17. **Which command can be used to record audio on a Raspberry Pi from a recognized microphone?**
    A. aplay
    B. ffmpeg
    C. arecord
    D. sox
    Answer: C. arecord

18. **If your webcam's microphone is recognized as card 2, device 0, which of the following commands records a 10-second clip?**
    A. arecord -D plughw:0,2 -d 10 test.wav
    B. arecord -D plughw:2,0 -d 10 test.wav
    C. arecord -D hw:2,0 -d 10 test.wav
    D. arecord -d 10 test.wav
    Answer: B. arecord -D plughw:2,0 -d 10 test.wav

Short Answer

19. **What is the command to play back the recorded audio file test.wav?**
    Answer: aplay test.wav

20. **If you cannot hear any audio on playback, mention one troubleshooting step you might try.**
    Answer:
    - **Check alsamixer to ensure the volume isn't muted**
    - **Ensure correct audio output (HDMI vs. headphone jack)**
    - **Verify the proper audio device is selected**

Section 6: Video Recording with ffmpeg

MCQs

21. **Which flag specifies the video input format when using ffmpeg on a Raspberry Pi with a USB webcam?**
    A. -i
    B. -r
    C. -video_size
    D. -f
    Answer: D. -f

22. **In the command below, what does the -framerate 25 parameter control?**
    ffmpeg -f v4l2 -framerate 25 -video_size 640x480 -i /dev/video0 output.mp4
    A. The bitrate
    B. The resolution
    C. The capture frames per second
    D. The audio sampling rate
    Answer: C. The capture frames per second

Short Answer

23. **Write a sample ffmpeg command to record a 30-second video clip from /dev/video0 at 800×600 resolution into a file called myvideo.mp4.**
    Answer: ffmpeg -f v4l2 -t 30 -video_size 800x600 -i /dev/video0 myvideo.mp4

Section 7: Virtual Environments & Python

MCQs

24. **Which command is used to create a Python virtual environment named myenv?**
    A. python3 -m venv myenv
    B. virtualenv myenv
    C. mkvenv myenv
    D. pip install myenv
    Answer: A. python3 -m venv myenv

25. **After creating a virtual environment, which command do you use to activate it on a Raspberry Pi OS (bash shell)?**
    A. enable myenv
    B. bash myenv
    C. source myenv/bin/activate
    D. activate myenv
    Answer: C. source myenv/bin/activate

Short Answer

26. **Why is it recommended to use a Python virtual environment when installing packages like opencv-python?**
    Answer:
    It prevents version conflicts by isolating package installations from the system-wide Python packages, keeping your global environment clean.

Section 8: Motion Detection & OpenCV Basics (Advanced/Optional)

MCQs

27. **Which OpenCV function is commonly used to convert a frame to grayscale?**
    A. cv2.absdiff
    B. cv2.cvtColor
    C. cv2.threshold
    D. cv2.findContours
    Answer: B. cv2.cvtColor

28. **In a simple motion detection script using OpenCV, which function is used to find the outlines of detected shapes or movements?**
    A. cv2.GaussianBlur
    B. cv2.dilate
    C. cv2.absdiff
    D. cv2.findContours
    Answer: D. cv2.findContours

Short Answer

29. **Briefly explain what the following line of code does in a motion detection script:**
    frame_delta = cv2.absdiff(gray1, gray2)
    Answer:
    It calculates the absolute difference between two grayscale frames, highlighting areas where changes (motion) occur.

30. **What is one practical use of a Python-based motion detection system on a Raspberry Pi?**
    Answer:
    - **Home security or surveillance**
    - **Wildlife monitoring**
    - **Triggering automated tasks when movement is detected**

Section 9: General Troubleshooting & Best Practices

MCQs

31. **If the webcam video is lagging or dropping frames, which of the following might improve performance?**
    A. Increase resolution to 4K
    B. Lower the frame rate
    C. Use a lower resolution

D. Switch to the composite video output
Answer: C. Use a lower resolution

Short Answer

32. **Name two commands or methods you can use to check the CPU and memory usage on your Raspberry Pi when troubleshooting performance issues.**
    Answer:
    - **top or htop**
    - **free -h**
    - **(vcgencmd measure_temp for temperature)**
33. **Why might you need to install haveged on a headless Raspberry Pi when enabling VNC?**
    Answer:
    It provides additional entropy for secure operations (including SSH/VNC) when there is little keyboard/mouse input, preventing entropy starvation.

Section 10: Additional Open-Ended/Discussion Questions

1. **Explain how to configure the Raspberry Pi 400 so that it automatically logs in upon boot and starts the desktop environment (useful for kiosk-like setups).**
   ***Answer will vary. Consider using raspi-config or editing config files to auto-login*.**
2. **Discuss how changing contour area thresholds in a motion detection script affects sensitivity and false positives.**
   ***Answer will vary. Lower thresholds might detect very small movements or noise; higher thresholds ignore small changes but may miss subtle motion*.**
3. **Propose a simple Python script flow that captures an image every 30 seconds and uploads it to a cloud service.**
   ***Answer will vary. A sample approach: use a loop with time.sleep(30), capture an image (e.g., with fswebcam or OpenCV), then upload via an API (AWS S3, Google Cloud, etc.)*.**

Lab 1 In-Lab questions (Found in the Github)

Section 5: Questions to think about

1. Identify and explain the additional functionalities introduced in Code #2. How do these changes transform the program from a simple image capture to a movement detection system?
2. Several new OpenCV functions are used (like cv2.absdiff, cv2.cvtColor, cv2.GaussianBlur, cv2.threshold, cv2.dilate, and cv2.findContours). Research each of these functions and understand their role in processing the video frames for movement detection.
3. The program uses specific conditions (such as contour area) to decide when to draw rectangles and indicate movement. Experiment with these parameters to see how they affect the accuracy and sensitivity of movement detection.
4. Loop Mechanics and Video Processing: Analyze the role of the while loop in the 2nd Code for continuous video capture and processing. How does this looping mechanism differ from the single capture approach in the 1st Code, especially in terms of real-time processing and movement detection?
5. Consider aspects like improving the accuracy of movement detection, optimizing performance, or adding new features (like recording video when movement is detected).

1. What additional functionalities are introduced in Code #2 compared to Code #1?

Answer:
Code #1 simply captures a single image from the webcam and saves it to disk.
In contrast, Code #2 introduces a continuous **loop** that captures and compares consecutive frames in real time. It detects movement by calculating differences between frames and highlights motion by drawing rectangles around moving objects and displaying a "Movement" status. This transforms the program from a basic image grabber into a **real-time motion detection system**.

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2. What does cv2.absdiff(frame1, frame2) do?

Answer:
This function calculates the **absolute difference** between two frames.
It highlights the pixels that have changed between the frames—indicating possible movement.

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3. What does cv2.cvtColor(diff, cv2.COLOR_BGR2GRAY) do?

Answer:
It converts the difference image from color (BGR) to **grayscale**.
This simplifies the data by reducing the number of channels, making further image processing faster and more efficient.

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4. Why is cv2.GaussianBlur() used in the motion detection process?

Answer:
cv2.GaussianBlur() applies a blur to the grayscale image to **reduce noise** and minor pixel fluctuations.
This helps in avoiding false positives by smoothing out insignificant variations.

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5. What is the role of cv2.threshold() in detecting motion?

Answer:
cv2.threshold() converts the blurred image into a **binary black-and-white image**.
Pixels brighter than a certain value become white (motion), and others become black (background), helping to isolate movement areas clearly.

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6. What does cv2.dilate() do in this context?

Answer:
It **expands white regions** in the binary image, helping to **fill in gaps** and make motion areas more solid.
This improves contour detection by ensuring small holes or noise don't break apart moving objects.

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7. What is the purpose of cv2.findContours() in Code #2?

Answer:
cv2.findContours() identifies the **outlines of white regions** (areas of motion) in the image.
Each contour corresponds to a detected moving object.

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8. Why does the code check cv2.contourArea(contour) < 900?

Answer:
This condition filters out **small contours**, which are likely caused by noise or minor changes.
Only contours larger than 900 pixels are considered significant enough to count as real movement.

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9. How does adjusting the contour area threshold affect the system?

Answer:

- A **lower threshold** increases sensitivity but may cause false alarms from small or irrelevant movement.
- A **higher threshold** reduces false positives but might miss subtle motion. Tuning this value balances **accuracy** and **sensitivity**.

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10. How does the loop in Code #2 enable real-time processing?

Answer:
The while True: loop **continuously captures and processes frames** from the webcam. Each frame is compared to the previous one, and any detected motion is immediately displayed. This allows for **live monitoring**, unlike Code #1, which only takes one snapshot.

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11. How does Code #2 differ from Code #1 in terms of structure?

Answer:

- **Code #1**: Captures one image, saves it, and exits.
- **Code #2**: Uses a loop to constantly read new frames, detect motion, and update the display, enabling **ongoing surveillance**.

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12. What are some ways to improve the motion detection system?

Answer:

- **Accuracy Improvements:**
    - Adjust blur kernel, threshold values, or contour area.
    - Use background subtraction or adaptive thresholding.

- **Performance Optimizations:**
    - Lower frame resolution.
    - Use multi-threading or hardware acceleration.
    - Optimize frame rate or processing frequency.
- **New Features to Add:**
    - Automatically **record video** when motion is detected.
    - **Send alerts** via email or app notifications.
    - **Log timestamps** and store data for reviewing past events.

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13. What is the overall impact of these changes in Code #2?

Answer:
Code #2 transforms the application from a simple image capture tool into a **fully functional motion detection system**.
It enables real-time surveillance, processes video frames to detect changes, and provides the foundation for advanced features like automated recording and alerts.