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Mini-Project 3 Module 6: Correct System Behavior

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Project Scope

A home security system can do a lot of good. Its primary use-cases involve detecting break-ins and having an alarm system that can be used to alert authorities for help. A video security system, with enhanced capabilities gained from image processing, such as identifying number of people or perhaps, with robust imaging technology, recognizing if people are household members or strangers. All of these great solutions, however, depend on an uninhibited video system. Herein lies our mini project focus: ensuring the video system maintains this "correct system behavior."

Possible Issues

Some of the key considerations to determining that the system is fully functional are: low lighting, frozen video, camera moved, camera shutdown, insufficient power supply, sudden video loss/power spike, WiFi signal interruption & interference. When one or many of these issues arise, it threatens the systems ability to accurately, if at all, detect anomalies in the video data.

Implementation

To monitor the live video surveillance system's functionality, we've built a module using the OpenCV library in Python which serves as a basic system monitor as well as a tampering detection measure. The module repeatedly tests for four different conditions: low lighting, frozen video feed, camera POV shift, and loss of connection to video feed.

Alert Logs

The foundation of the module lies in its Alert Log functionality. The alert logs are text files that hold alerts such as "Low Lighting Warning" or "Video May Be Frozen," along with a timestamp indicating when the alert was triggered. Alert logs are initialized using datetime values, so there will be one alert log for every day - all with different file names. In order to make the alert logs more active (so the user doesn't have to manually open and read through them), the module has three conditions under which it will send an email to the user containing the current day's alert log contents. The module will email the alert log to the user if it's the end of the day, if the user presses the 's' key while viewing live video, and if the system loses its connection to the video feed.

Alert Triggers

The module has four conditions under which an alert will be added to the current day's alert log. The first is a low lighting warning, as it can be more difficult for machine learning algorithms to detect people in poorly-lit frames. This is triggered when the mean brightness of the frame drops below a given threshold. The second condition is a frozen video warning, to indicate that the video feed is only sending one frame instead of constantly updating with new frames. This is detected by saving the current frame in a list, then a few seconds later testing the new current frame against the saved one. If the similarity of the two frames is high enough, the module writes an alert to the alert log. The third condition is a POV shift warning, to indicate that the camera may have been moved. This is detected by using the similarity function from the frozen video detection in each of the four corners of the frame. If the maximum similarity of the four corners drops below a certain threshold, an alert is written to the alert log. This is probably the most likely condition to produce false positives, due to the fact that moving objects could enter and leave the corners of the image at times when the frame is saved. The final condition is if the module loses its connection to the video feed. This results in an OpenCV error, which is caught via regular exception handling in Python. When this error occurs, the module writes "Camera Connection Shutdown" to the alert log and immediately emails the alert log to the user to inform them of the system failure.

Opportunities for Further Work

Video loss due to insufficient power supply, power spike and WiFi signal interruption and interference are not included in the module, but it would be beneficial to incorporate alert mechanisms that are responsive to those possibilities in the future. Hypothetically, if built off from the existing module, insufficient power supply can be detected by decreasing FPS of the video feed. So a threshold for FPS can be set then the error can be captured by regular exception handling. An alert should be recorded to the alert log and an email should be sent to the user. On the other hand, power spike can be seen as the opposite case to insufficient power supply, where FPS suddenly increases in a short time period. This can also be captured by exception handling and recorded to the log as long as it doesn't affect the system's functionality over time.

Impact

If the data is at all compromised, the overall system cannot achieve a meaningful outcome for the end-user. By resolving these live video data issues, we enable the other components of the overall product to succeed and in turn help secure homes.