Developing and Building a Stabilization System for Body-Worn Cameras

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Imagine looking through hours of recorded footage, trying to find just one small detail. However, the recorded footage is shaky and blurry, making it difficult to watch and hard to analyse. This is one of the biggest challenges facing body-worn cameras today and solving it would drastically improve the usability of these cameras. So, is there a way to stabilize the footage, making it possible to watch even the most intense situations?

BACKGROUND

Body-worn cameras are increasingly used in uniformed occupations, such as law enforcement and security. The cameras allow the wearer to document events as they unfold, increasing accountability and helping to clarify what actually happened. To effectively do this, the recorded footage should be as clear and stable as possible, which is where the problems arise.

Since the cameras are attached to the wearer, they will move with the body as it turns and rotates. No matter how well secured the camera is, these movements will cause vibrations and disturbances, which degrade the quality of the recorded footage. This effect is even more pronounced in intense situations with quick movements, such as a police officer chasing a suspect. It is also in these situations that clear and stable footage is needed the most.

BUILDING A PROTOTYPE

To tackle this challenge a stabilization system suitable for body-worn cameras was developed. First the types of movements and disturbances that most commonly affect these cameras were analyzed, identifying shortcomings of existing stabilization technologies. This led to the chosen concept of a gimbal-based solution as the most viable option. Gimbals are mechanical image stabilization systems that utilize rotational motors and sensors to keep the camera module level. This existing technology was adapted to create a prototype specifically designed for the needs of body-worn cameras.

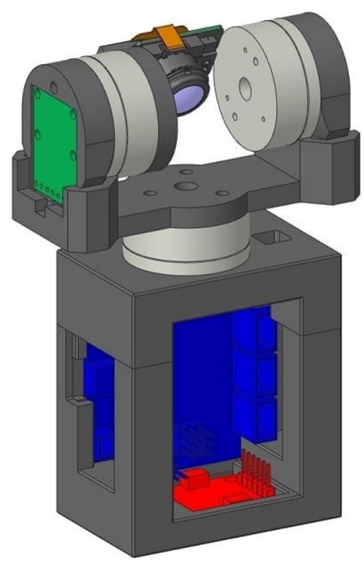

Fig. 1: CAD model of the final prototype

The process of designing and building the prototype included custom software, 3D printed parts, and electrical components. Several iterations of prototypes were made throughout the project, resulting in the final design shown in figure 1. The design is able to rotate the camera module both horizontally and vertically, making it a two degree of freedom system. It is also in these two rotational direction, that the largest disturbances acting on the camera have been measured.

Controlling the prototype

In addition to designing the prototype, the required controller was also investigated and implemented. The investigation can be split into two parts. The first part is how the motors are controlled, which was achieved by using the Field-Orientated Control (FOC) algorithm. FOC is an advanced mathematical method for controlling the behavior of electrical motors. Using FOC, the angular positions of the motors can be controlled with precision while minimizing current consumption.

The other part needed to control the prototype, is knowing which direction the camera should be pointing in. Through testing of the prototype it was decided that the camera should point in what was named the forward direction. The simplest way to define the forward direction is to see it as the wearer's overall heading. This direction will change overtime, as the wearer is not expected to walk in a straight line. To dynamically update the forward direction, the averages of the sensor's directional readings were fused in a complementary filter.

The result

Combining the constructed prototype with the controller design, results in the final prototype seen in figure 2. It was tested by walking and running towards an object in the distance, with the stabilization turned on and off.

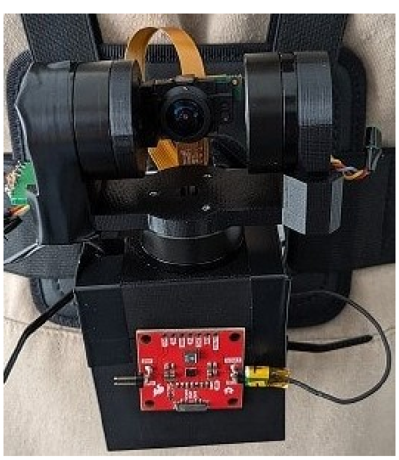

Fig. 2: Final prototype

Figure 3 provides an example of the results, displaying a snapshot of the recorded footage along with a traced black line. The black line represent the deviation of the tracked object relative to its position at the start of the recording. Any deviation of the object is caused by the camera moving during the test. The black line can therefore be used as an estimation of the stability of the footage.

(a) Stabilization Off (b) Stabilization On

Fig. 3: Tracking the movement while running

Ideally, the black line should be a single point, indicating that the camera stays completely level and stable during the test. As the results in figure 3 show, the prototype is not able to completely eliminate the disturbances. It does however demonstrate that the overall area of the black line is reduced, both horizontally and vertically. This result demonstrates the usefulness of the proposed stabilization system and confirms that body-worn camera footage can be stabilized. A more in depth investigation is needed to perfect the system, but the results presented in this article clearly show the possibilities of implementing a mechanical image stabilization system in a body-worn camera.

To read a more thorough explanation of the image stabilization system discussed in this article, a Master thesis is available with the name *Developing Stabilization System for Body-Worn Camera* written by the same authors.