Development of a Mechanical Image Stabilization Method to Counter-act Rotational Disturbances

By

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The footage recorded with Body-worn Cameras is not worth much if the footage is shaky, blurry and indecipherable. Introducing stabilizing elements aid in reducing disturbances and produces stable footage. A challenge when attempting to implement stabilization is the size of the solution, and one way to address this might be to develop a new actuator.

The characteristics of the disturbances exerted on a Body worn Camera are mainly governed by the wearer's movement pattern. When running, the movement of the torso adds a rotational disturbance to the footage, which in a periodic manner adds deviation to the direction the camera faces. When each foot hits the ground, a disturbance in the vertical direction is introduced. To address these issues, a two-part mechanical stabilization system is implemented.

The active system

To address the disturbance with the most impact, namely the horizontal, rotational motion, an electromechanical system is designed and prototyped. The objective with this system is to keep the size of the final prototype in mind in all stages; during component selection, layout of said components and the prototype being a foundation for an alternative actuator. The micro-controller used is a Raspberry Pi Pico (RP2040) due to the small size as well as the large storage capacity. This component served as the main control unit for all components, receiving the angle of the body, the angle of the actuator and outputting the required voltage to counter-act the angle deviation. The active system design included circuit design, CAD and programming of the micro-controller. While the programming was rather straightforward, a few iterations of the CAD model and circuit layout were needed. In figure 1, the prototype is shown.

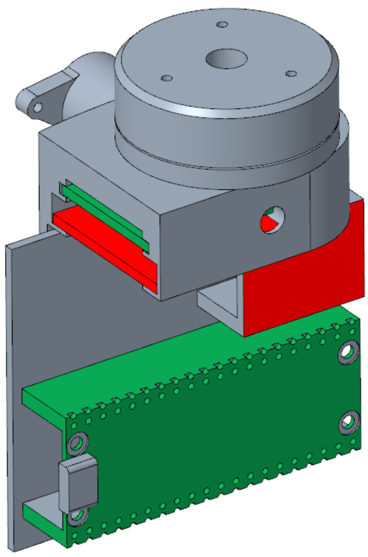

Figure 1: CAD model of the prototype for the active system.

The coloured parts are the electrical components used. The control system is developed using Field-Oriented Control (FOC), with a directional awareness algorithm to keep track of the forward position when walking or running in different directions. To power the system, a 3.7V battery is used and the current use is 55 mA when idle. When actively controlling the angle, less than half of the idle current is used at most.

The passive system

The passive system was designed to address the vertical disturbance, and the initial idea was to use a material as a cushion for the impact between the camera and the attachment solution. Through testing it was found that the cushioning effect wasn't achieved. However, the passive system served a purpose for stabilization as it stiffened the cameras attachment to the body. With this function established, two different materials were tested and evaluated against each other, polyethylene (PE) foam which is rather soft, and silicone which has a higher stiffness. The results show an improvement by using silicone instead of PE foam.

The combined system

In Figure 2, the results of the two-part system in action is shown. The deviations from the center point are measured in pixels within a 1920x1080 frame. The disturbances in the horizontal coordinate was reduced by 66.1% and 44.1% in the vertical coordinate.

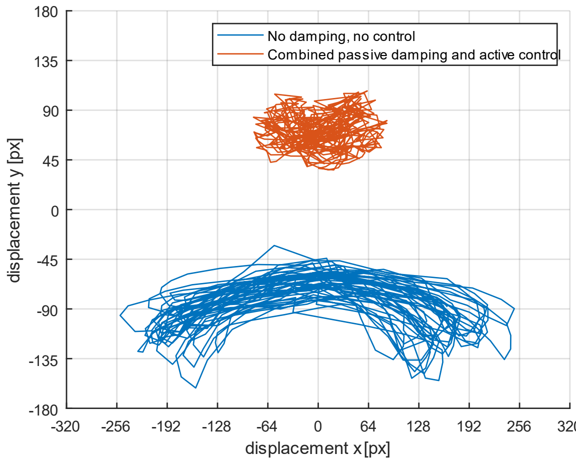

Figure 2: Blue: No damping and no control, Orange: Silicone damping and active control

An alternative actuator

As a final step in the thesis, and as a foundation for future work, an alternative actuator was conceptualized. The concept is based on disk drive voice coil actuators, due to the limited angle needed and the ability to make them small and still output the required torque. Through calculations, the number of windings were calculated and reiterated for different currents, based on the data gathered from the active systems prototype. The governing equation for this is the Lorentz Equation (Eq. 1). After establishing the number of windings and other dimensional requirements, simulations were conducted and finally a CAD ideation of the actuator was conceived. In Figure 3, the CAD-model of the actuator is shown. In Figure 4, the torque achieved, as well as the flux linkage, are plotted as functions of angle and current. This implied that the actuator needed utilize current control to achieve a current between 40 and 60 mA to encompass the required angle span.

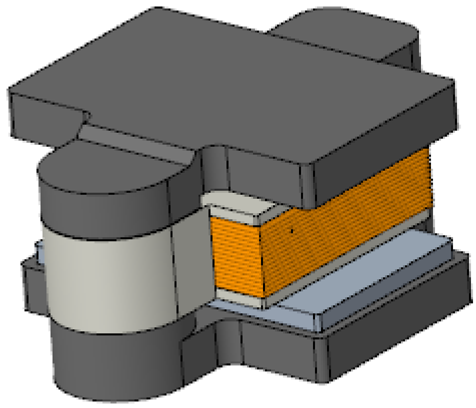

Figure 3: The CAD-model of the actuator.

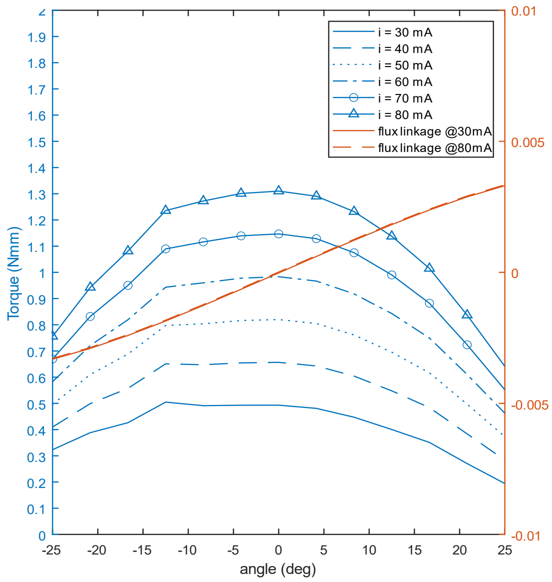

Figure 4: The torque and flux linkage as a function of current and angular position.