Camera Stabilizer

by

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Abstract:

The goal of this project is to create an affordable camera stabilizer (the “stabilizer”) for consumers to use with cell phones or GoPro cameras. The stabilizer compensates for two axes, pitch and roll, as well as vertical movement. The system (currently only compatible with one cell phone model) is handheld and uses a combination of brushless DC motors, an Inertial Measurement Unit (IMU), and a microcontroller to compensate for the operator’s movements, stabilizing the phone for non-shaky, high quality video recording. The stabilizer provides a low-cost alternative to professional stabilization solutions employed in the production of feature-length films; the system is designed for amateur video producers and enthusiasts to have access to physical camera stabilization. The final system is also intended to provide higher quality stabilization than the rudimentary physical (i.e. springs and counterweights) or software (post-production) solutions available now.

The stabilizer should run on 11.1V LiPo or NiMH batteries and require essentially no input from the user; only an “on” switch or plugging in the batteries should be necessary.

Introduction:

In EE 462 the team built upon the progress of the previous quarter by ordering replacement motors and components necessary for the transition from breadboard to perfboard circuit implementation, and using CAD to create drafts of the stabilizer's mechanical frame. Once all components were soldered onto the perfboards and tested, a first true working prototype was built by mounting the perfboards and microcontroller onto the mechanical frame. Software debugging and improvements were made throughout the quarter.

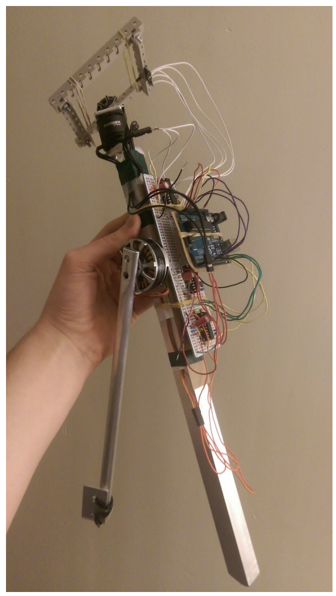

Figure 1: Functioning prototype

Product Market:

According to embedded systems engineering research, there wasn't a market for 3-axis MEMS gyroscopes prior to 2009, but now the market is expected to reach about $1.57 billion by 2017 (**Figure 2**). This product is an active system, and the market for 3-axis MEMS gyroscopes is aligned for active, electronic camera stabilizers. However, the target market for this product includes both passive and active systems; the entire stabilizer market. The main issue with drawing exact figures in this case is that the passive system market is comprised mostly by movie studios, which don't release data to the public. Therefore, it is assumed that that portion of the market is segregated (customers only buy within that market). **Table 1** displays the customer's expected to be interested in this project.

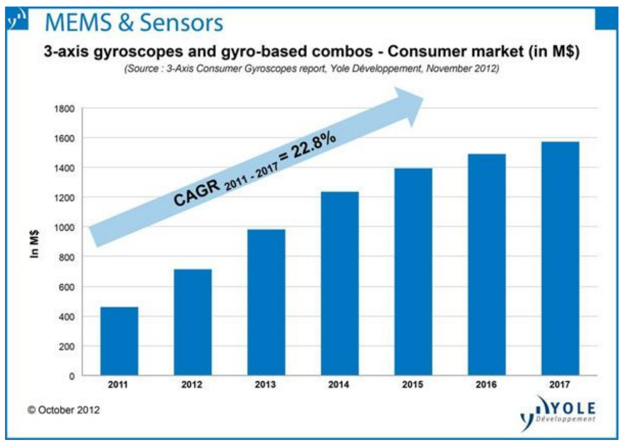

Figure 2: Market Increase for 3-Axis Consumer Gyroscopes

Table 1: Camera Stabilizer Customers

	Description	**Reason**	**Product Use**
YouTubers	People who post daily or weekly to YouTube with a significant following.	They would want easy to use technologies that create high quality videos that their viewers appreciate.	• Portability and simple to use. • Be recorded without visible camera shake.
Amateur Filmmakers	People who enjoy making videos, documentaries, etc.	They are on a small budget and this could be used in replacement of expensive DSLRs.	• Record using a cell phone. • Easy to record moving scenes.

Business Aspects:

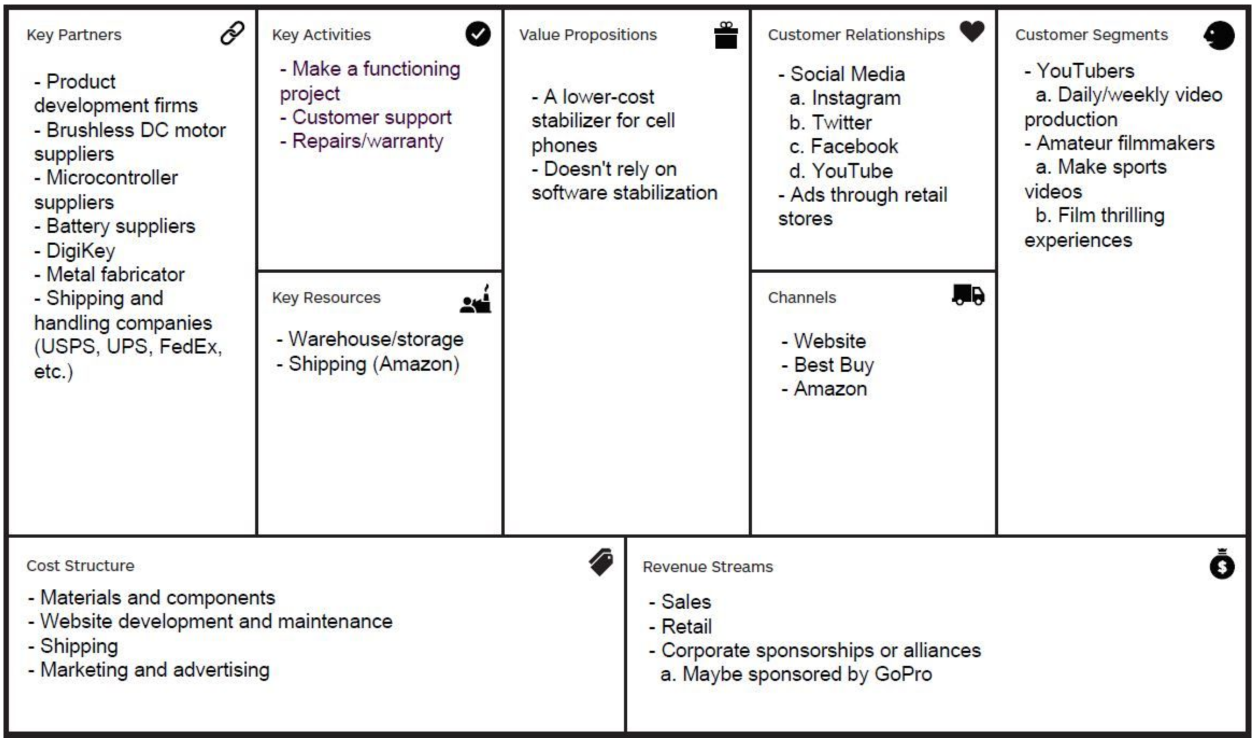

Figure 3: Business Model Canvas

The market size for stabilizers (in terms of units sold) is relatively small; big-budget films generally use SteadiCam stabilizers ($10,000+) and consumer use of stabilizers is limited to hobbyists and amateur filmmakers. Therefore, this product is aimed toward a market size that is closely related but still early in development because this product is suited toward an “average” (non-technical) person. Handheld camera stabilizers that are less than about $10,000 in cost and can account for full XYZ movement seem to not exist based on research. This project works to capitalize on this window of opportunity by providing a very low cost (<$400) product, designed for ease of use by typical consumers.

Product:

Table 3: Marketing requirements translated to Engineering requirements

Marketing Requirement	Engineering Requirement
Retail Price $399 (prototype costs ~$213, expect production cost under $150)	Arduino: $50 Battery: $30 3x Motors: $70 3x L6234 ICs / components: $40 IMU: $8 Structural parts: ~$15
Minimal adjustments or components to arrange prior to use	Self-centers on boot
Compensates for 2-dimensional movement	Roll and pitch (Y-Z axes) are adjusted using brushless DC motors.
Easy to operate by one person	Only one handle; weight under ~5lbs
Battery life lasts for approximately two hours.	Provides 2100mAh at 11.1V
Internal components (microcontroller, etc) won't be affected when being used.	Microcontroller, battery, and perfboards are not in the way of the handle.

Build:

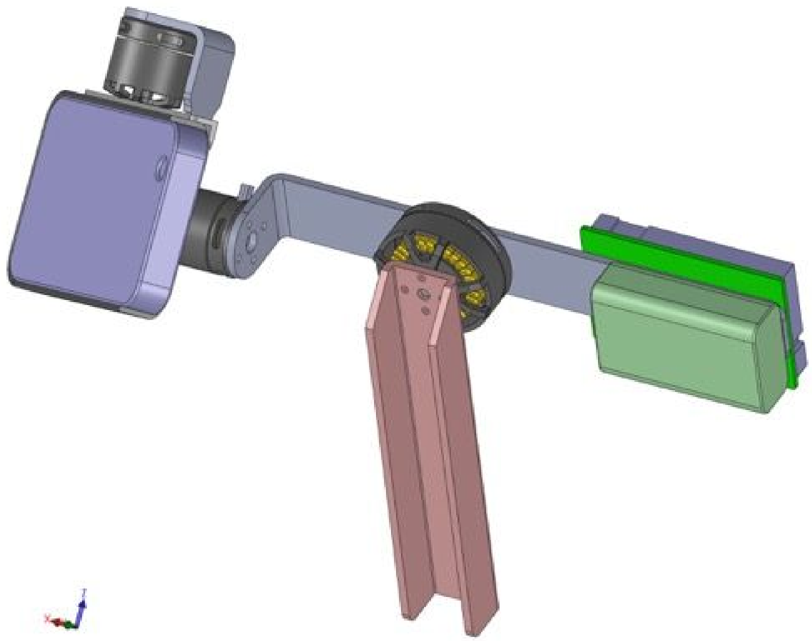

Figure 4: CAD mockup of the stabilizer

An Arduino Mega 2560 microcontroller represents the “brains” of the stabilizer. Three L6234 motor driver ICs are used to drive the three brushless motors on the stabilizer. The Arduino takes orientation and acceleration information from the MPU6050 Inertial Measurement Unit (IMU) and uses it to compute the necessary motor movements to keep the camera stabile.

Figure 4 shows a 3D model of the design. The vertical center beam is where the user holds the stabilizer, connected to the frame through a large brushless DC motor. The boxes on the right side represent the battery pack and electronics (Arduino and motor driver circuits). The box to the far left represents the cellphone to be mounted on the stabilizer, connected to the frame by the pitch motor (topmost) and roll motor, aligned with the central frame.

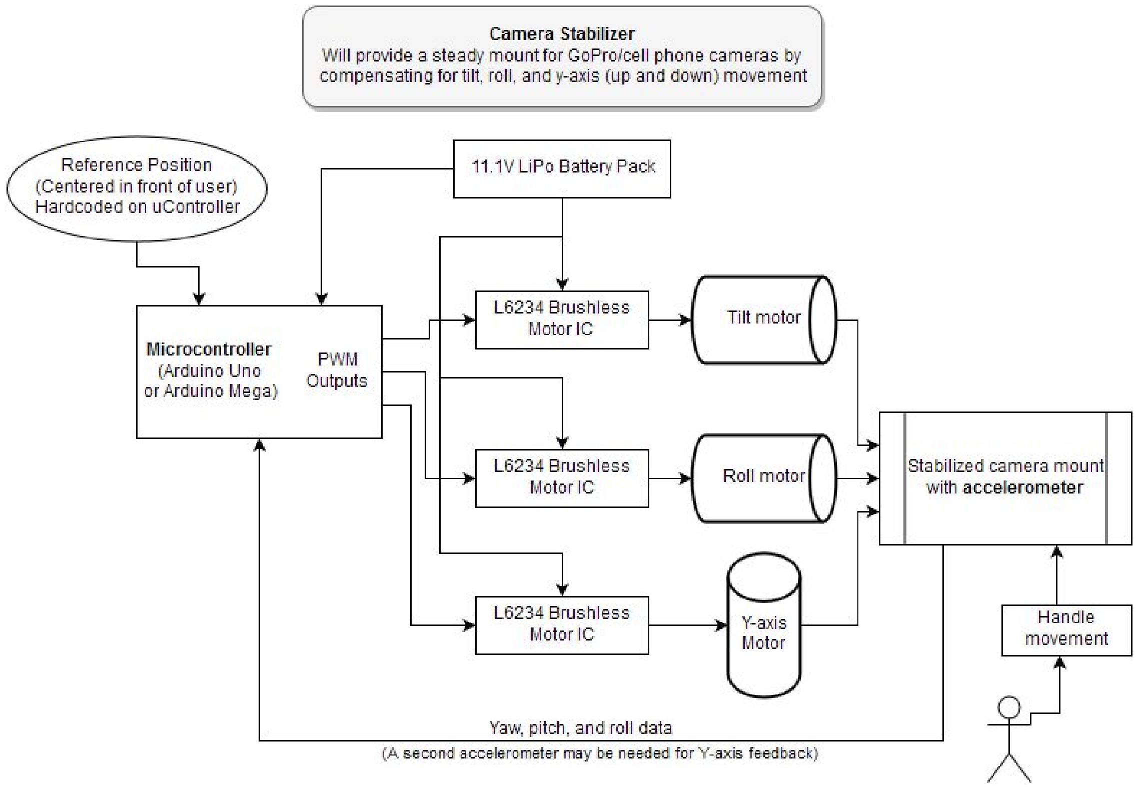

Figure 5: System block diagram

The basic control of the motors is covered by PWM outputs, selected from a sine wave lookup table. Each motor receives 3 PWM signals, one for each phase. By stepping forward or backwards through the sine wave table, the motors can be turned forward or backward, respectively.

At the most basic level, stabilization is achieved by measuring the orientation of the camera, then moving the motors such that the camera is again vertical and facing forward. As an example, if the camera is tilted 15° forward, the tilt motor would be rotated 15° in the opposite direction to re-level the camera. In the stabilizer, this is accomplished through PID control implemented in software on the Arduino. As a quick recap, PID control uses the direct measurement (ie number of degrees the camera is away from vertical) along with the velocity and acceleration of movement. By using higher order physical quantities, the system can provide fast correction for quick user movements, without oscillations or instability.

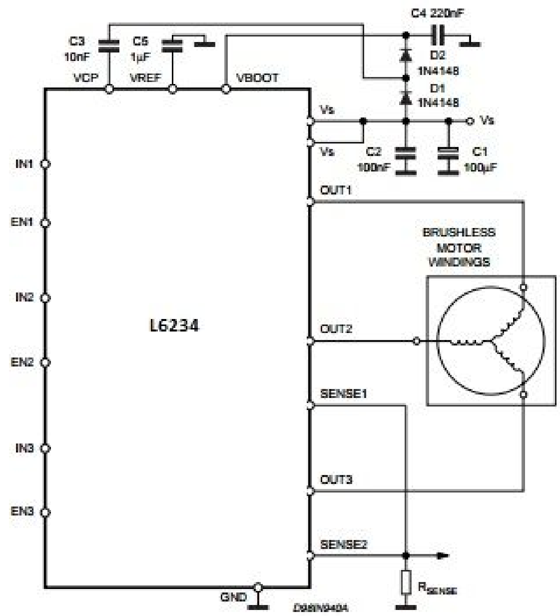

Figure 6: Motor IC schematic

Each motor is driven by a circuit identical to **Figure 6**. The sense resistors are 0.25Ω to allow for the ~0.5A output per motor, while offering shutdown protection in the event of a short circuit or other high-current event.

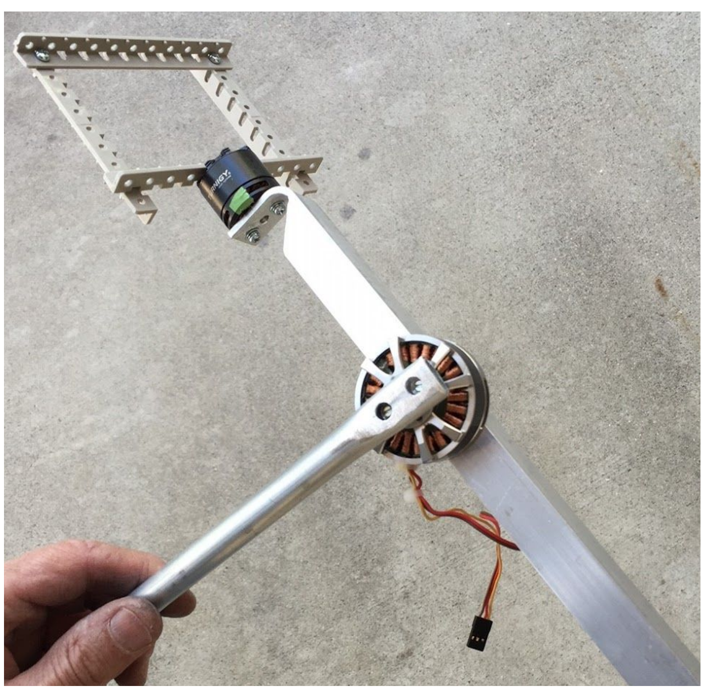

Figure 8: Initial frame and motor placement (pitch motor added later)

The first components of the physical frame are shown in **Figure 8**. The frame is constructed from aluminum for both ease of work and to provide lightweight strength. The final product would use injection-molded plastic for even lighter weight and better consistency.

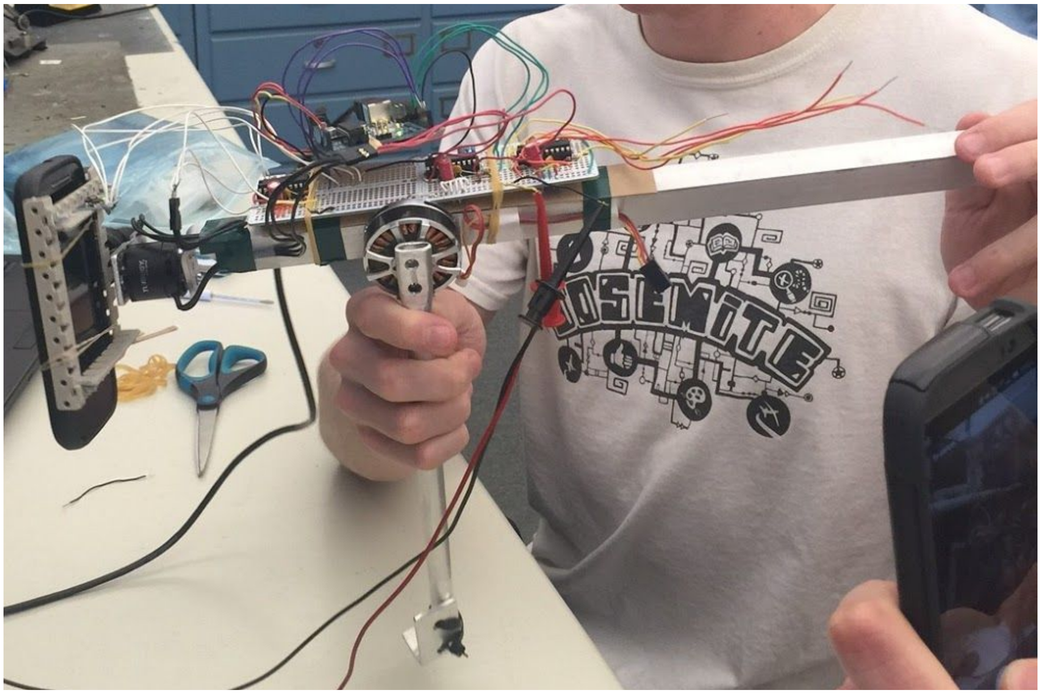

Figure 9: First assembled prototype

The initial prototype is shown in **Figure 9**. This prototype was built before batteries and the Arduino Mega 2560 were added. The disconnected wires to the right of the electronics are for the large central motor, which the smaller microcontroller in the picture did not have enough outputs for. In addition, once the battery packs were added to the “open” end of the frame, the system could be held without holding the frame for balance.

Improvements:

A final completed product would come with its own rechargeable battery. The layout of the perfboards, microcontroller, and other visible components and wiring would be improved such that they are more out of sight and contained in some sort of casing or cage. Another improvement would be the ability of the system to stabilize other products, like all other kinds of cell phones and GoPros. This would be accomplished through an interchangeable mount and adjustable frame.

Conclusion:

The goal of developing a low-cost camera stabilizer for the consumer market is attainable, and given 6-12 more months of development, this project could be turned into a full-fledged consumer product. The vertical stabilization aspect, however, would need to be replaced by yaw compensation; this would provide better real-world performance, and make the stabilizer both smaller and lighter. Given the popularity of “everyday” people making their own videos for YouTube, a system this inexpensive (<$400) could be a gateway into a market which is essentially untapped. In addition, the software used to control the camera stabilizer could be easily adapted to stabilizers outside the “handheld filmmaker” realm, such as drone photography and videography. This licensing (or expanded product line) would provide for lucrative increases in market share served.