February 21st, 2018

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Re: ENSC405W/440 Functional Specifications for **CidaFrame**

Dear Dr. Rawicz,

The following document describes the functional specifications of CidaFrame, prepared as a course requirement for Team 6 of the ENSC 405W portion of the capstone course. Our goal with CidaFrame is to create a cost-effective, modular, and smartphone compatible alternative to automatic camera tracking of a subject.

The document will cover the mechanical, electronic, and software requirements of CidaFrame. A breakdown of the requirements into various stages which we hope to accomplish is also included. This outlines what we expect to achieve for our proof of concept, and for our final prototype at the end of the 8-month capstone course.

Contained within the specifications are details about CidaFrame's system requirements, such as the IR sensing and tracking system, the motor systems and physical design for panning and tilting the camera, and the modularity for compatibility with different cameras and tripods/stands/tabletops.

We are Telaio Technologies, a diverse group of five students with Systems, Electronics, and Computer Engineering backgrounds: Reese Erickson, Waez Dewan, Neijer Shokri, Jon De Guzman, and Jason Liu. We hope to achieve

Thank you for your time in reviewing the functional specifications of CidaFrame. Feel free to contact us at jdeguzma@sfu.ca if you have any additional questions.

Sincerely,

Reese Erickson

CEO

Requirement Specifications

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Abstract

Modern consumption of digital multimedia is a large part of all of our lives. The backbone of this consumption are the creators of all of the videos we watch, of which there are many. The Internet and modern smartphones facilitate a large number of people to create and share video with their friends and family, and the public, for any purpose. These videographers range from amateurs with simple smartphones, to professionals with high-end recording equipment. Some of the conveniences available to the professionals aren't currently available to regular consumers, and the members of Telaio Technologies believe that our skills and experiences will allow us to fill a gap in the market, for cheaper, cost-effective automated camera tracking of a subject.

This document contains the functional specifications and requirements for Telaio Technologies' cost-effective automatically tracking camera mount, CidaFrame. Consideration for all aspects of our device, ranging from physical shape to tracking software, is contained within. From this document, the reader should be able to understand the function and the higher-level design of the product. We believe that our solution

CidaFrame consists of two physically separate components, one of which is the camera mount, and the other being the tracking device. The physical design, controls, electronics, and tracking software requirements of both components will be described in depth within this functional specification document. Additionally, timeline-dependent requirements for each of the stages we expect to develop our product to, such as a proof of concept followed by a prototype, will be included, so we can prioritize earlier work on more core functional requirements.

Telaio Technologies is dedicated to creating a cheaper, modular, cost-effective tracking camera mount to allow for use with both smartphones and digital/other cameras. This document is our description of what is required of such a product.

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1. Introduction

CidaFrame is an automatic mount for any handheld directionally-dependent device, such as a phone, camera, or microphone. The primary feature is a sensor system which locates the tracker, panning and tilting to aim the mounted device at the tracker. A motorized two-axis mount is the core of the movement, while a modular design will facilitate holding various devices of the user's desire for recording, as well as permitting the use of the CidaFrame on top of a standard tripod. By simply wearing a tracking device, which also functions as a simple controller for the mount, the user will be able to quickly calibrate the mount with the push of a button, and toggle the tracking functionality on and off, allowing for autonomous camera operation and allowing for more than just a stationary, immobile shot.

1a. Scope

This document will describe all of the requirements that Telaio Technologies must meet in order to accomplish the overall goal of the product. It will outline the physical, electrical, and software requirements needed while highlighting the functionality of CidaFrame. Some of the requirements and functions that are described may have changes made to them, due to possible improvements or unforeseeable issues during the development of the product. By following the requirements outlined within this document, Telaio Technologies as a whole will have a reference to monitor development of the product.

1b. Intended Audience

The functional specifications here are to be used by the engineers of Telaio Technologies during the development of CidaFrame as well as the professors/TA's supporting us in this course. Referencing the document during development work will help to guide efforts towards producing what we initially set out to create, clarifying the details and resolving any possible confusions along the way. Quality assurance, testing, and marking after any stage of development has been completed can also be done referring to this document, as it compiles a list of functions that we require of our product.

1c. Classification

For clarification and prioritization of our requirements, the following convention will be used to describe requirements:

[R{section number}.{priority/stage code} - {requirement number}]

The section number will indicate that the requirement falls within the description provided in the table below. The requirement number is an increasing number to uniquely identify the requirements within that section and priority combination. The priority/stage code is to indicate whether the requirement should be met in a proof of concept, a prototype, or a production model. Higher priorities (smaller numbers) indicate that the requirement is important to CidaFrame's core functionality. Requirements for an earlier stage (e.g. proof of concept) will apply to later stages as well (e.g. prototype and production model).

Additionally, any requirements with a requirement number in the range of 1000-2000 are safety and sustainability requirements. These may have any of the section codes (whichever is most relevant), but are numbered in that range to easily identify them.

Section code	Description
P	Physical (hardware)
E	Electronic
S	Software
G	General

Table 1: Section Code Descriptions

Priority	Description
1	Proof of concept
2	Prototype
3	Production model

Table 2: Priority Descriptions

2. Glossary

IR - infrared

EM - electromagnetic

“Mount” - portion of CidaFrame which holds the camera and may be on a tripod

“Receiver” - portion of CidaFrame attached to a moving subject

3. System Requirements

3a. General Requirements

For any retail product claiming to be cost-effective, the price is one of the most important things after the actual functionality in order to be a successful product. We will set a modest goal of creating a product that is cheaper than $300, which is less than half as expensive as the competing products [1] [2], and ideally this is to be even better than that. Additionally, for our product to be accessible to smartphone users, it must also be simple enough to operate for any smartphone owner. We expect that people potentially down to the age of 13 whose parents have bought them a smartphone may want to record a home video with tracking functionality, so we have set a requirement that our device is simple enough to operate for an average teenager.

In order for our tracking mount to be useful in at least a minimal set of cases, the tracking method should have a set operating range. From our regular usage of smartphone cameras and the like, we estimated that a minimum viable indoor tracking range of 3 meters must be feasible using our device, with a larger tracking range being better. Additionally, for adequate framing of the subject and receiver, the tracking system must be accurate to within a certain angle. For our proof of concept, the angle of the receiver detected by the system should be accurate to within 15 degrees of the actual position of the receiver. The prototype will more accurately detect the correct angle, and we will narrow this position down to 5 degrees. No guarantee will be made if the system is used in a situation where IR is reflected easily by nearby surfaces (such as in a mirror maze), which may cause false signals and result in inaccurate position detection.

As we plan on using wireless technologies to perform tracking and data transmission in our system which should be compatible with smartphones, we must also not disturb regular operation of a smartphone mounted atop the device. This would defeat the purpose of having phone compatibility in the first place.

General Requirements - Proof of Concept

[RG.1 - 1] The system shall consist of a motorized camera mount, and a receiver to be worn by a subject.

[RG.1 - 2] The system must be functional indoors.

[RG.1 - 3] The mount will be able to detect the angle of the receiver relative to it to within 15 degrees.

[RG.1 - 4] The mount, when on and running, must pan/tilt itself to point within 15 degrees of the receiver.

[RG.1 - 5] The system will be able to perform tracking with line of sight when indoors between the receiver and transmitter at a minimum of 3 meters away.

[RG.1 - 6] The system must not disturb a smartphone in close proximity to it with the IR and RF/Bluetooth transmissions.

General Requirements - Prototype

[RG.2 - 1] The mount will be able to detect the angle of the receiver relative to it to within 5 degrees.

[RG.2 - 2] The device, after the mount is secured and turned on, must be functional within 30 seconds.

[RG.2 - 3] The device must produce under 40dB of noise when in use.

General Requirements - Final Product

[RG.3 - 1] The price of the final product must be under $300.

[RG.3 - 2] The product will ship with a simple instruction manual.

[RG.3 - 3] The device must have simple button/switch controls, such that almost any smartphone owner can understand the controls.

[RG.3 - 4] The product will have at least one associated web page for online-available instructions.

[RG.3 - 5] The device may be functional outdoors.

[RG.3 - 6] The device must have a functional battery life of more than 1 hour.

3b. Physical Requirements

For CidaFrame to be viable to carry around with other camera equipment, and be placed on top of most tripods comfortably and not to be cumbersome, the device must have a weight of under 1 kg. This way, users will not feel burdened by carrying the device along with them, and not have an awkward setup of the system -- in most cases a single user will be operating the product, and will need to be able to set up the system alone and with ease. The weight limit for our prototype is an important consideration for development and final product design in order to be attractive to users who would be interested in using the system.

On a similar note, to eliminate potential hassle of setup and use to a single user, the physical size of the device must also be within a reasonable limit. For our prototype, we may not be able to meet the most stringent size requirements due to using and integrating multiple off-the-shelf internal components, but we hope to confine the stand portion of our prototype within a $30cm^3$ volume. The physical size of a viable product must be smaller than this, and to be competitive, should likely be a similar size to other existing auto tracking mounts, such as the PIXIO [1] and the SOLOSHOT [2]. Other products on the market have also addressed size considerations, and in order to be a competitive product, we must keep in mind our size restrictions when designing the final product, and identify room for improvements wherever possible.

With two axes of rotation, two separate actuators will be necessary to control both the pan and tilt functionalities. As mentioned previously, weight and size considerations are heavily prevalent in design, and will need to be considered when choosing actuator specifications and placements in the internal housing of the product. By choosing placements such that the product's center of gravity is kept central to the body of the device, a smoother pan can be achieved without needing as much braking power as if the center of gravity were positioned less centralized. More in depth, we aim to reduce the torque required to change the angular momentum of the moment of inertia for the center of gravity about the point of rotation for panning the camera. As the torque required is proportional to the moment of inertia, which is proportional to the square of the distance of the center of gravity to the axis of rotation, reducing necessary torque required by decreasing this distance will allow for a smaller actuator needed, which reduces cost of materials, and weight specification for the product. Maintaining our goal of keeping a centralized center of gravity, our placement of our tilting actuator will need to be positioned such that it is not too far radially from the axis of rotation to pan, and that tilting is achieved in a structurally efficient way that will not cause too much stress on the actuator. Two designs have been considered for the placement of the tilt actuator, and the method of achieving such a rotation, which are shown in Figure 1 below.

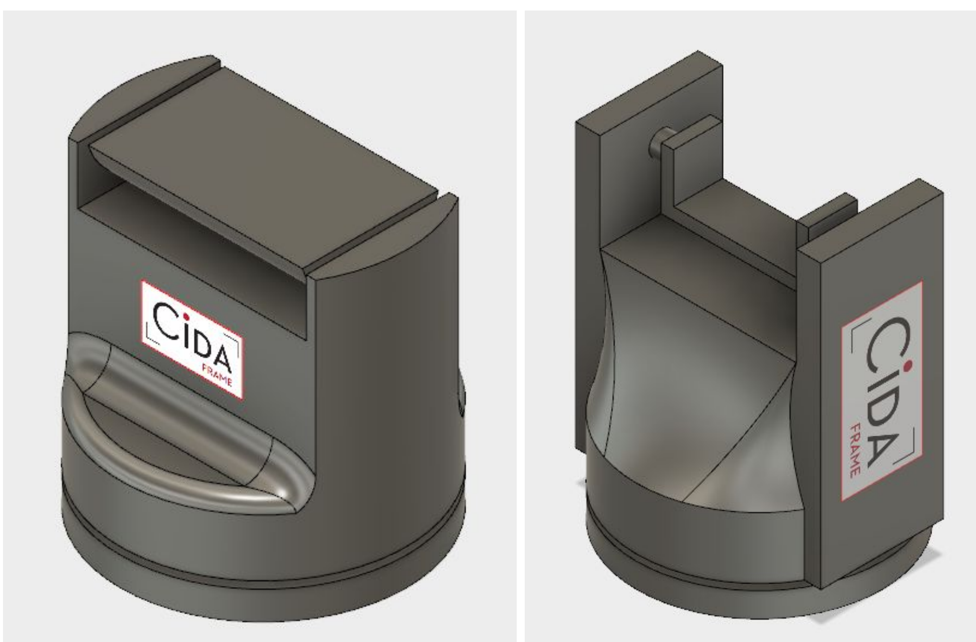

Figure 1: Two potential models with different methods of tilting considered

Considering the size restriction of the cameras that would be mounted on the device, primarily being smartphones, the two potential styles of the product considered differ in the sense of limiting size of what will be mounted. As shown, the method displayed on the left has a larger mountable size restriction over that shown on the right. While the surface on the left is flat, it has not been decided how the mounting would look like, but features a larger range nonetheless. In order to achieve rotation for tilt, as that shown on the right is directly attached to the mount, a direct rotational motion can be translated from a motor through gearing through the side arm. However, the method on the left would involve a different method of achieving the rotation, and keeping contact with the mount. A high level, more in-depth display of how the rotation could be achieved is shown in Figure 2 below. If a gear was positioned below the tilting surface, which would also have teeth for the gear to connect to, the actuator could be mounted more central to the device. Additionally, the peg shown on the front into the arced inlay shows a possible way of maintaining structural integrity of the mount, without the surface falling off. The arced inlay also provides hard stops at physically determined rotational limits. Being able to determine these tilt axis limits physically allows for redundancy, and allows for a failsafe if the tilt fails where the mount will not only rely on electromechanical components to stop motion.

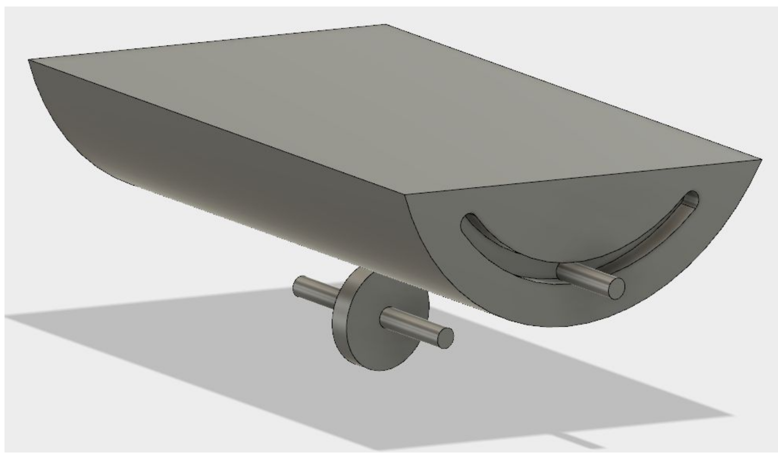

Figure 2: In-depth view of where tilt motion will be translated from for one model

Additionally, key considerations for actuators is a method of feedback to generate position information. While we intend to use motors for each method of rotation, a rotary encoder will be the most natural choice of feedback. Possible options for rotary encoders would involve either digital or analog means, using a rotational optical encoder as an example for a digital encoder, and a rotary potentiometer as an example for an analog encoder. A key consideration for choosing an encoder is the operational range of the actuator being measured, as well as the information received at startup of the device -- further, can the position be measured through the encoder, or kept track through the microcontroller based on incremental signals received.

As our tilt will not be able to achieve a full rotation, a limited rotary potentiometer would be a good choice, as they are inexpensive solutions with position feedback that would be calibrated upon the assembly of the device. However, as we will allow full rotational motion for the panning actuator, a different type of encoder will be necessary. Servo potentiometers are available, which do not have a limit on rotation. Other possibilities include resolvers, or optical encoders. All potential options carry pros and cons associated with them, which will need to be analyzed further upon the decision of which method will be used. In order to have a competitive advantage with the current devices in the market the following will be the specifications of the device.

Physical Requirements - Proof of Concept

[RP.1 - 1] The mount must weigh less than 4 kg.

[RP.1 - 2] The mount must fit within a 30cm^3 volume.

[RP.1 - 3] The receiver must weigh less than 0.5kg.

[RP.1 - 4] The receiver must fit within a 10cm^3 volume.

[RP.1 - 5] The mount must support holding at least one model of modern smartphone (smartphones released between 2014 and 2017).

Physical Requirements - Prototype

[RP.2 - 1] The mount must weigh less than 1 kg.

[RP.2 - 2] The mount must fit within a 20cm^3 volume.

[RP.2 - 3] The receiver must weigh less than 0.2kg.

[RP.2 - 4] The receiver must fit within a 5cm^3 volume.

[RP.2 - 5] The mount must support at least 3 models of modern smartphones (released between 2014 and 2017).

[RP.2 - 6] The mount must be attachable to a standard tripod screw (1/4 - 20 UNC).

Physical Requirements - Final Product

[RP.3 - 1] The mount must support at least 10 models of modern smartphones using the modular head.

3c. Electronic Requirements

The first prototype will not require using battery power, but will be intended for the implementation of the final product. However, for either the prototype or full product, in order to electronically isolate the constantly operating processing chip, sensors, and emitters from the higher-power and more intermittently operating motors and their drivers, we plan to use isolated sources of power for the CPU and motor drivers. The CPU will only send control signals to the drivers, where the supply power to the motors will be provided through a separate source than to the CPU, illustrated in Figure 3. By isolating power sources, we expect to achieve a lower error when monitoring sensor values from the CPU.

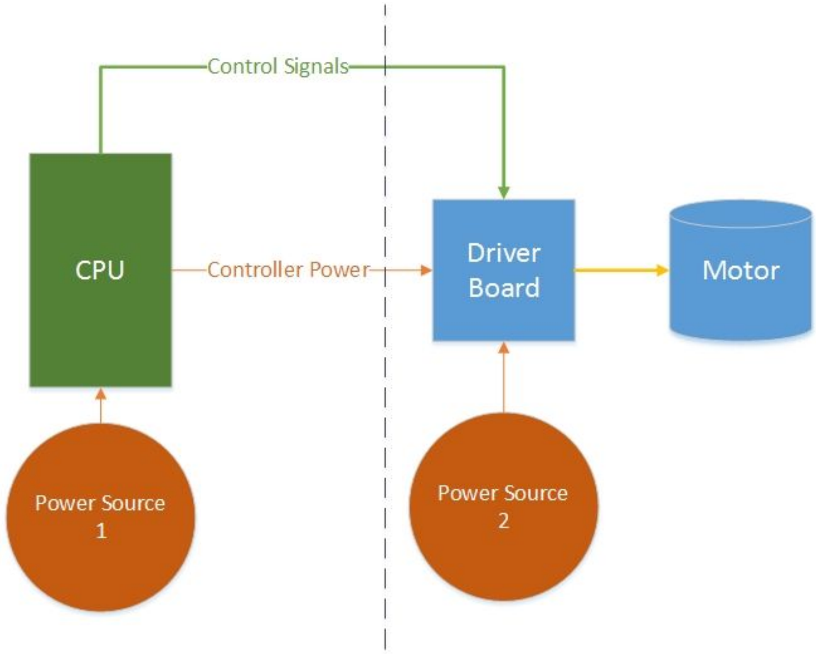

Figure 3: Block Diagram of motor control with power supply isolation

The idea of having separate power sources stems from one group member's experience through powering sensors and motors off of the same source, and the noise introduced by doing so. Outlined in [3], isolating power sources from sensitive processors, along with their respective sensors being monitored, from inductive loads (motors) reduces associated noise to the system, and protects sensitive circuitry from reverse-voltage. A typical motor driver implements various methods of protection between the load and the controller, which introduces additional isolation along with the separate power supplies.

A potential product [4] features a dual onboard driver with temperature, voltage and current protection. A cost-effective solution, the board offers two separately controllable channels for two different motors to be controlled individually -- ideal for using with the pan and tilt actuators. Additionally, one mode of use allows for electronic braking with PWM control, reducing the need for external braking circuitry.

After having identified our power source isolation in order to reduce noise induced in the sensor readings, we must identify which sensors we will be using, and where they will be connected to and powered from. As we intend to use a stock microcontroller for our prototype, we have access to its onboard voltage regulation circuitry. While we make sure to keep the controller powered, we can use the regulated voltage source to power active sensors along with transmitters and receivers.

The sensors that will be used will need to give important information about the system in terms of position of the object being tracked, and where the tracker is in terms of its pan and tilt motion. As explained in the physical requirements section previous, encoders give feedback information to give the system a sense of its position. Most encoders are active opposed to passive, which require power in order to send feedback signals. In [5], methods of gaining rotational position feedback are explained, including optical encoders, and magnetic rotary encoders. Using quadrature encoding of any of the available methods is also available in order to gain directional information. Having two sensors reading in the same position with a slight offset allows for a known positional delay in reading the signals, and when compared between the two allows for directional feedback information.

Available magnetic rotary quadrature encoders can be mounted directly to the motor shaft, allowing direct sensing of speed and position tracking. For these encoders, feedback signals will be monitored from the microcontroller, while power is applied to the encoder from the onboard voltage regulator supply from the microcontroller.

In terms of the tracking of a subject, electronically the system will need receivers and transmitters for IR, and potentially another means of wireless data communication. In order to track the subject, we intend to place an IR transmitter on the prototype with a receiver and transmitter at the subject, which requires another receiver back at the prototype. In total, we will need two pairs of transmitter and receiver pairs. With onboard power available at the prototype off of the microcontroller and control signals available to send, the placement of the pair is more of an issue to consider. However, at the point of the subject, it is necessary to have a low power, basic control circuit in order to relay where the subject is in relation to the prototype.

Electronic Requirements - Proof of Concept

[RE.1 - 1] The mount and receiver must run off of separate power sources.

[RE.1 - 2] The mount, when fully active (panning, tilting, and tracking) must draw under 20 watts.

[RE.1 - 3] The voltages within the system must be at most 12V.

[RE.1 - 4] The IR sensors on the mount and tracker shall have a range of at least 3 meters when in line of sight.

[RE.1 - 5] The data transmission method from the tracker to the mount shall have a range at least as large as the IR sensing range.

[RE.1 - 6] The pan motor and its driver shall be able to pan the mount when holding a load under 300g at a minimum angular velocity of 30 degrees/second (5 RPM).

[RE.1 - 7] The tilt motor shall be able to steadily hold up to a 300g modern smartphone at an angle of up to 45 degrees leaning forwards/backwards.

[RE.1 - 8] The tilt motor and its driver shall be able to tilt the mount with up to a 300g load at a minimum angular velocity of 22.5 degrees/second (3.75 RPM).

[RE.1 - 9] The IR emitter on the mount shall scan the front facing area at a minimum of 5 times per second (300 RPM).

[RE.1 - 10] The microcontroller and drivers must be capable of individually operating 3 motors for pan, tilt, and IR emitter rotation.

[RE.1 - 11] The microcontroller must have sufficient memory for the software required of tracking.

Electronic Requirements - Prototype

[RE.2 - 1] The mount and the receiver shall have externally accessible controls to control the system.

[RE.2 - 2] The mount and receiver must be able to turn off to conserve power.

[RE.2 - 3] The mount and receiver must run off of battery power.

[RE.2 - 4] The mount and receiver must have individual battery lives of over an hour.

[RE.2 - 5] The mount and receiver must turn on within 30 seconds.

[RE.2 - 6] The motors in operation must not produce a noise level greater than 40 dB.

Electronic Requirements - Final Product

[RE.3 - 1] The mount and receiver must both run off of rechargeable battery power.

[RE.3 - 2] The mount and receiver must both have charging circuits and a plug to allow charging using a readily available plug type.

[RE.3 - 3] The mount and receiver must have similar battery lives, and must have battery lives of over two hours.

[RE.3 - 4] The mount and receiver must be operable during charging of the batteries.

[RE.3 - 5] The IR transmitter and receiver may be operable in outdoor conditions, with a minimum range of 3 meters with line of sight.

[RE.3 - 6] The microcontroller may have WiFi/Bluetooth capability to enable wireless communication with other devices aside from the tracker.

3d. Software Requirements

The software will be required to approximate the position of the tracker relative to the current position of the mount as accurately as possible using the calibrating point on the scanning IR transmitter, a timer, and the data from the receiver. With the approximated position, the signals must then be sent to pan the camera mount to correct for any existing offset between the calibrated “center” of where the tracker should be relative to the sensor, and the current position of the tracker relative to the sensor.

The microprocessor in the board should be relatively inexpensive, and for the purposes of our proof of concept, we intend on using an off-the-shelf Arduino. As this has a relatively limited flash memory for storing the running software, the software must be small enough to fit in the microprocessor.

Making the device easy to operate out of the box does not necessitate removing all possible functionality from the hands of the user. Individual control by the microprocessor of each of its motors, as well as the panning/tracking ability (turning that off),

For the tracking to be adequate for a moving subject, the software should be able to compute the location from one set of data within 0.1 seconds.

Software Requirements - Proof of Concept

[RS.1 - 1] The software in the mount must have a startup time of under 10 seconds.

[RS.1 - 2] The software in the mount must compute the approximate location of the tracker given the available sensor data and an on-chip timer.

[RS.1 - 3] The memory footprint of the software must be under 32kB.

[RS.1 - 4] The software must be able to control the pan and tilt motors, as well as the IR emitter motor.

[RS.1 - 5] The software must be able to recompute the location of the tracker at least 10 times a second (software computation time for a single tracker scanning must not exceed 0.1 seconds).

[RS.1 - 7] The software must be able to turn off its tracking and panning ability without turning off the device entirely.

[RS.1 - 8] The software must handle cases where the IR waves are blocked and cannot receive feedback gracefully (no continuous actuation/wasting energy).

Software Requirements - Prototype

[RS.2 - 1] The software must be well-documented and maintainable, with sufficient code comments.

Software Requirements - Final Product

[RS.3 - 1] The software in the mount may be capable of communicating with a smartphone app through bluetooth.

[RS.3 - 2] The software in the mount may be able to receive input to manually pan/tilt when the tracking functionality is turned off.

4. Safety and Sustainability

Our intention with CidaFrame, if it is to become a commercially sold product, is to initially sell to a Canadian market. For the purposes of our proof of concept or our prototype, we are not planning on any commercial distribution of any kind. However, we are considering this as a possibility, and we may more extensively look into Canadian federal regulations regarding our device in the future. Currently, at a glance, the nature of the functional purposes of our device are relatively harmless.

As we will be transmitting EM radiation both to and from the receiver (through IR and radio frequency/Bluetooth) which may be worn by a person, the radiation must be within safe limits for humans to be in direct exposure to. As we intend on using off-the-shelf components for both the IR and the wireless communication back, these safe limits will be very easy to stay within. The frequency/wavelength ranges included in these wireless transmission methods are also commonly found in many similar products at similar power levels, such as our own cellphones, and the TV remote control.

From additional research we did, the Health Canada article [6] has indicated that the safety range for devices with a magnetic field is in the frequency range of 0.003MHz to 10MHz. This values are subject to change based on the environment and the type of devices used. Considering these ranges for precaution however based an article by World Health Organization [7], there is no real evidence produced by many devices currently in the market in creating risks in biological responses and well being.

Smartphones are relatively expensive devices, and in using our device, a user's smartphone should remain relatively safe. At the very least, our device must not directly cause damage to the user's mounted device when being panned/tilted. Dropping of the phone, or detachment of the mount from a proper tripod must not occur under correct installation situations, and we intend to guarantee this within our proof of concept for the device.

Despite the product being inexpensive, Telaio Technologies does not wish to create a device which works for a short period of time before failing. For a final product, we will guarantee that the device lasts for at least 100 full charge cycles, and under regular occasional usage (less than once per day, more than once per week), will last at least 2 years.

As our device contains electronic components, including a microcontroller and 3 small electric motors, these components may pose a shock/fire hazard. To mitigate the fire hazard, we will require that the mount under full operation stays within a reasonably safe temperature limit (50C). Additionally, the prototype and the final product must adequately protect the user from potential electric shock with casing that does not easily expose any of the internal components.

Safety & Sustainability Requirements - Proof of Concept

[RP.1 - 1001] The mount for the smartphone must not drop the smartphone when subjected to regular panning/tilting.

[RP.1 - 1002] The mount, when attached to a tripod, must not spontaneously come detached from the tripod during regular operation due to panning/tilting.

[RE.1 - 1001] The electronics, under full operation, must stay under 50 degrees Celsius.

Safety & Sustainability Requirements - Prototype

[RP.2 - 1001] The mount for the smartphone must not drop the smartphone when subjected to minor vibrations, and regular panning/tilting.

[RP.2 - 1002] The mount and receiver must not have unnecessarily sharp edges and corners, to minimize wear and tear on said corners and to reduce risk of injury.

[RG.2 - 1001] The receiver must be safe as a wearable device (under 8V, under 10mA, fully enclosed electronics).

[RE.2 - 1001] The battery and electronics, under normal operating conditions, must not pose a fire/explosion hazard.

Safety & Sustainability Requirements - Final Product

[RG.3 - 1001] The packaging shall display a warning for the receiver as a choking hazard.

[RG.3 - 1002] The packaging shall display a warning for the moving parts of the mount.

[RG.3 - 1003] The packaging shall display adequate labelling for the batteries used.

[RG.3 - 1004] The product shall conform to the labelling standards detailed in ISO 28219:2017.

[RG.3 - 1005] The product shall, under occasional usage (less than once per day, more than once per week), last at least 2 years.

[RP.3 - 1001] The mount/receiver must exhibit similar durability to physical damage as the devices they hold, such as a phone. Short (under 2ft) drops onto carpet should not damage the device.

[RP.3 - 1002] The mount must be robust to manual rotation, and not break when rotated.

[RE.3 - 1001] The electronic system must be robust to manual rotation of the motors, and not be destroyed by human turning of the motors.

[RE.2 - 1002] The battery shall sustain a minimum of 60% of its original capacity over no fewer than 100 charge cycles.

5. Conclusion

The CidaFrame is to be an affordable, modular, and simple solution to provide automated tracking for a camera. With the help of this device, general users can add automatic pan and tilt tracking to their videos using their smartphones and not spend large sums of money on professional equipment to achieve the same results.

The requirement specifications includes the following main sub sections:

- Physical Requirements to showcase what we require of the physical structure of the device.
- Electronic Requirements to provide high level of electronics parts in designing of the devices and communication between the mount and the receiver.
- Software Requirements to detail the software involved in the tracking and panning functionality, as well as the software controls.
- Safety and Sustainability Requirements to ensure the safety of the user and their monetary goods, and the sustainability of our device.

This document will be used as a reference throughout the development and testing phases of the device. All of our requirements have been classified into stages for our proof of concept, prototype, and a theoretical final product.

6. References

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Appendix

The functionalities we intend to present in our proof of concept are listed in the similarly named requirements above, under section code 1. For convenience, this appendix contains a short description of the core functionalities we intend to bring to our proof of concept.

From the general requirements, we intend to produce two working components. One is our motorized, tracking camera mount, and the other is a target receiver to be tracked. The system will be functional indoors, and the mount will detect and pan to point at the receiver to within 15 degrees. A minimum range of 3 meters is to be expected, when line of sight is available between the tracker and receiver. Additionally, we plan on using one of our group members' phones to test our device, and the phone should fit properly in the device.

Physically, our proof of concept should weigh less than 4kg for the mount, and 0.5kg for the receiver. The mount should be contained within a $30cm^3$ volume, and the receiver within a $10cm^3$ volume. We chose larger physical requirements for the proof of concept so that we would be able to focus on and demonstrate the tracking and panning ability without having to worry too much about packaging the system.

Regarding the electronics, the mount and receiver in our device must run off of separate power sources. Wall outlets are likely to be our power source, as for the proof of concept, the intent is to demonstrate the tracking and panning. Certain speed requirements of the panning, tracking, and tilting motors must be met, and a minimum of a 3 meter range on the wireless communications between the mount and receiver is required.

Our main software requirement is such that the software fits into the device's memory. Our initial design idea was to use an Arduino, and as it has limited flash memory, we will need to keep the software small enough to fit into memory. Reasonable start times of 10 seconds for the electronics and software are to be expected of our proof of concept, to avoid long waiting times for a user. The software must have full control of the device's motors and sensors to achieve the tracking functionality, and must also be able to toggle this functionality. It must also be sufficiently fast as to not lag far behind the physical position of the receiver. Graceful failure case handling in the software (e.g. when the receiver is not in line of sight) must be present as well.

Lastly, in terms of safety, our proof of concept will securely hold onto one of our phones (not dropping it), and be securely attached to a tripod, while the aforementioned functionality is demonstrated. We also expect to meet an upper temperature limit of 50 degrees Celsius during operation of our device.