**//Technical Concept Report**

//Technical Summary:

Turning Helper is a thoroughly designed sophisticated sensor and displaying device that detects the turning direction of the vehicle and displays a front, right, and left turn arrow correspondingly. Biking Helper is composed of 3 Arduino Uno boards, 2 Bluetooths, four 16\*16 LED display boards, a voltage Regulator modules, an audio player，a 12V battery, two switches, and a three-positioned switch.

Our competitiveness lies in several key technical and innovative concepts. They are VRM (**V**oltage **R**egulator **M**odule) -oriented turning detection and graphical decoding to set the color and brightness of each light bulb on our display screen.Our innovative technologies are made possible by Bluetooth communication, Serial communication circuit, IIC (Inter-Integrated Cirvcuit), and ADC converting technologies. With our key innovative technology of VRM-oriented turning detection, we are able to detect the facing of the vehicle. And with our graphical decoding algorithm, we are able to decode the digital image to commands for the display board, which in coordination with the Arduino Uno Board saved up all crucial space in which the original lunch box-sized LED Processor-decoder took up.

With a simple Velcro add-on, users can tape the display screen onto any flat surface including backpacks, insulated delivery cabinets, and even jackets or vests. And with an easy tuck, users can lock the truing detection device onto the handlebar of their vehicle, providing our users a great experience with our simple-to-follow and easy-to-build manual instruction. After setting up, users should face their bike straight forward and wait 2-3 seconds for the Bluetooth to connect. The automated turning display and manual truing display functions could then be performed with our VRM-oriented turning detection system and three-positioned switch.

Well, how are the fore-mentioned functions performed? Specifically, as the bicycle is head is turned to an angle more than 15 degrees to the left or right of the forward position, the VRM (**V**oltage **R**egulator **M**odule) will provide a resistance of smaller than 450 if turned to the left and a resistance greater than 550 if turned to the left. If these resistance levels are detected, then our algorithm will determine weather it is a right or a left turn, storing it as an integer from 1-3. However, if the users manually input a turn by changing the state of the three-positioned switch turn states will be judged on the manual input instead. After determining the turn state of the vehicle, the Uno board sends the state as an integer to the display board via the auto-pairing bluetooth. Finally, if the latest turn state send is different from the last turn state send, the display board will change the arrow image to another arrow image through our innovative graphical decoding algorithm.

//Need Statement

41 000 cyclists are killed and while cycling to school, work, a shopping centre, or home every year. Bike and E-bike accidents still remain one of the most pressing issue for road safety, and even more pressing, is that none of this seem to see a turn for the good. According to WHO, over the past ten years, bicycle and e-bike incidents around the world have increased by 37 percent.

This issue has been especially evident in China. China hosts more than 300 million e-bikes, which is stilling increasing at a rate of 30% every year, and around 1 billion bikes. In combination of China’s underdevelopment of biking lanes and crowded streets, e-bikers and bikers often are reluctant to wait for lights or the slow-moving pedestrians. As a result, they take unsafe routes that intertwine between roads and streets and often cross red lights, putting pedestrians, motor-vehicles, and themselves in grave danger. And just in 2020 e-bike and bike accidents in China has accounted more than 20,030 injuries and 245 deaths, a 30% increase compared to 2016. This trend especially apparent for China’s take-out deliverers. With more than 7 million take-out deliverers averaging 30 deliveries every day, these take-out deliverers has generated more than 3,000 deaths and injuries just in the past 6 months.

These loses are not only devastating in terms of human casualties and loses but also causing huge financial loses. And according to Science Daily, US bike accident has mounted to more than $20 billion per year and it is still climbing at a rate of $789 million per year.

Since bicycles do not have the auxiliary equipment often found in motor vehicles when riding, it is diﬃcult to inform nearby pedestrian vehicles when turning and changing travel speed, so traﬃc accidents can easily occur in such situations, especially for take-out-deliverers in China. In view of such needs, we have designed this bicycle steering alert system which incorporates both an automated turning alters system and a manual steering system.

<https://www.who.int/china/activities/protecting-chinese-e-bike-users-from-road-injuries-and-deaths>

<https://www.chinatimes.com/newspapers/20211205000880-260106?chdtv>

<http://www.xinhuanet.com/2020-09/14/c_1126492962.htm>

<https://bjgy.chinacourt.gov.cn/article/detail/2018/02/id/3198969.shtml>

<https://apps.who.int/iris/rest/bitstreams/1314375/retrieve>

<https://www.dpa-international.com/topic/cyclists-die-battery-powered-bikes-statistics-show-urn%3Anewsml%3Adpa.com%3A20090101%3A190724-99-185969>

//Background Technology

The design of the Turning helper builds upon the Bluetooth wireless connection technology, serial communication, embedded systems, laser cutting, and irregular flash patterns. First, for the design of the automated turning detection system and of display board we applied the technological concept of **Embedded Systems** to design both systems. Then for the exterior mechanical design, we used the **CAD** (Computer Aided Design) software to design the mechanical segments of our product and utilized **CNC** (Computer Numerical Control) **Laser Cutting technology** to create these parts. Next, for the communication between the automated turning detection system and the display screen we utilized **Bluetooth technology** to connect the VRM to the display board, transferring the data with the communication technique of **Serial Communication**. Finally, for the display of the turning signal we decided to apply the concept of I**rregular Flash Patterns** for the displaying of the direction arrows.

**Embedded system** is a combination of computer hardware and software embedded in a larger system. Embedded systems are low-cost, low-power-consuming small computer which is generally comprise of a processor, power supply, and memory and communication ports. Embedded systems use the communication ports to transmit data to other devices, usually other embedded systems, using a common communication protocol. We took on the concept of Embedded systems to design our automated turning detection system and display system as it is easy to manage in terms of the materials used to make these devices. These materials are cheap and long-lasting, requiring less maintenance. Furthermore, not only are embedded systems small in size they can also complete tasks swiftly and reliably as our embedded systems are assigned to only one specific task each. More importantly, Embedded systems are cost efficient as they both in terms of their low-power consumption rates and low hardware costs.

**CAD**(**C**omputer **A**ided **D**esign) is the use of computer-based software to aid in design processes. CAD software can be used to create two-dimensional sketches or three-dimensional models. CAD digitalizes the manufacturing process and helps the designer's workflow by increase productivity and quality and level of detail in the design. CAD software outputs come in the form of electronic files, which can be then used for 3D printing or laser cutting.

After designing our product with the help of CAD softwares, we used **CNC Laser Cutting technology** to cut out our CAD design. Laser Cutting is the process of using a Laser beam to vaporize and melt materials. Computer Numerical Control (CNC) Laser Cutting uses optics, an assist gas, and a guidance system to direct a focused laser beam onto a specific point of a material. We chose to use CNC laser cutting as it completed workpieces quickly and accurately.

**Bluetooth** is wireless communication standard which allows electronic devices to connect and interact with each other. Bluetooth is designed for direct device-to-device connections, supporting a with a lower data transfer speed and connection distance. Bluetooth devices send and receive data in the form of radio waves at a rate of 720 Kilo bytes per second via a device called the Bluetooth Adapter. When two devices are trying to connect, they will search for a common frequency out of the 79 frequency channels through which they can send and receive data. And when such frequency is discovered, the devices will automatically connect. In our product, we used Bluetooth communication to connect the detection and display part of the Turing Helper. We decided to use Bluetooth communication for its wireless transmission of data and energy efficiency, as it has ultra-low power requirement. More importantly, Bluetooths incorporate Bluetooth radio which pairs considerably easily. There is no need to install additional software or driver to establish communication between Bluetooth-enabled devices and to setup process for two devices to communicate.

**Serial communication** is a communication technique where devices transfer data one bit at a time in a sequential order over a communication channel that came to life in the early 1980s. Serial communication is widely considered the simplest form of communication between a sender and a receiver. With a small number of conductors, the clock skew problem that often happens between different channels of communication not being able to synchronize is not an problem with serial communication. The Turing Helper use the serial communication as a technique for transmitting data gathered by the VRM to the display board. We do so as serial communication needs lesser numbers of conducting wires, hence reducing cost of the interface. Moreover, serial communication offers a simple interface between transmitting and receiving devices as it uses minute amounts of connecting wires, usually one, making it easy to implement.

**Irregular Flash Patterns** is the flashing of the lights in an interruptive and irregular pattern. In our design we applied this concept for the displaying of the direction arrows on the display screen. According to the Aalborg University’s Safety effects of permanent running lights for bicycles “*The incidence rate, including all recorded bicycle accidents with personal injury to the participating cyclist, is 19% lower for cyclists with permanent running lights mounted.*” Moreover, Edewaard DE (2018) concluded that “*flashing lights significantly increased visibility of cyclists to other road users”*. This study also set forth to explore which kind of flash pattern is most rapidly recognized by road users and found that it was a interrupted flash pattern that did so.

//Concept Details

In daily life, bicycles and electric bikes are a common means of transportation for people. Since bicycles do not have the auxiliary equipment often found in motor vehicles when riding, it is difficult to inform nearby pedestrian vehicles when turning and changing travel speed, so traffic accidents can easily occur in such situations. And According to WHO, 41 000 cyclists are killed and while cycling to school, work, a shopping center, or home every year.

In view of such needs, we developed a bicycle steering alert system for the scenario of bicycle steering. The device is mainly controlled by Arduino, and with the help of Bluetooth wireless connection technology, serial communication, embedded systems, laser cutting, and irregular flash patterns. The steering and auxiliary data collected by the turning detector which consists of both an automated and manual turning function, such as steering instructions, speed, and driving intentions, are sent to the Display Screen for processing. The steering information is then displayed on a high-powered digital dot matrix screen with an interruptive pattern, and the steering information is prompted by a voice announcement device. Our product is also water-resistant, able to withstand light rain (< 2.5 mm [0.098 in] per hour) for more than 8 hours.

First, as the user opens the display screen and the turning detection system, the two Bluetooth devices in both systems will automatically pair by finding a common frequency previously set by us. After pairing, the turning detection system’s first precedence would be to collect the input from the three-position switch where the user manually controls the direction arrow display with the buttons I, 0, II corresponding to a left, forward, and left motion or turning direction. However, if the input from the switch is zero of the middle position, indicating a forward motion, or if the bike experiences a change of direction from >15 degrees to <-15 degrees or vice versa then the system would operate under our innovative automated turning detection system which is of the second precedence. The automated turning detection detects the heading of the bike by using the VRM (**V**oltage **R**egulator **M**odule) which is connected to the front intersection node of the bicycle using a synchronizing line. As the bicycle head is turned, the resistance provided by the VRM is also going to change correspondingly. If the resistance detected is smaller than 450 ohms then the bicycle is going to categorize it as a right turn, where the heading of the bicycle is 15 or more degrees to the right of the vertical position. And if the resistance detected is more than 550 ohms then the bicycle is going to categorize it as a left turn, where the heading of the bicycle is 15 or more degrees to the left of the vertical position.

Now with the turning data collected, we share the stored motion states in terms of integers from 1-3 through our wireless Bluetooth transmissions with the embedded system of our display screen. Then the display screen system takes the current state of the bicycle and compares it to the previous state of the bicycle; if they are different, the display system would opt to change the display of arrows on the screen followed by a sound announcement, this process happens at a rate of 10Hz (10 times per second).

First, the display system produces sound announcement by evaluating the motion sate and sending the corresponding digital data stored in the system to the sound module. Then the sound module will play convert the digital data back to analog data through DAC (**D**igital-to-**A**nalog **C**onversion)

Then, to change the display of turning arrows on the screen we utilized our innovative technology of graphical decoding. To achieve. Graphical decoding, we implemented the LED control method where we controlled each LED light’s brightness and color individually by assigning all of them a unique ID. In order to display the LED direction icons, our solution divides each arrow icon into four parts and displays each part on the corresponding 4 smaller LED board that, together, makes our display screen. After receiving a motion state update, the algorithm takes the corresponding graphical arrow icon and overlaps the icon onto the display screen. Then the lights overlapping the graphics will be lit by through function control to achieve the display effect. In terms of programming language implementation, the brightness and color of each light are determined by setting the RGB values of each LED lamp.

Turning Helper is unique because it is a service that contributes to the battle against non-motor vehicle accidents, rather than a product. The final product that is produced through Turning Helper is unlike any other existing product. The current solution to deal with non-motor vehicle accidents are traffic policies and manual turning lights. The Turning Helper features the innovative automated turning system and LED a 32\*32’’ display board that both presents the motion of the biker and also acts as a flash light to increase visibility of the biker. This idea is revolutionary and unique, as the Turning Helper is a combination of innovative techniques and already proven techniques to prevent non-vehicle accidents mounted onto one produce that is easily assembled and compatible with backpacks, vests, and insulated delivery cabinets.

Every great product requires thorough experimental tests and comparisons. Accordingly, we have run an abundance of examinations throughout our building stages with our algorithm and manual controls. When we completed the device, we furthered our testing and invited pedestrians to try out product and had them compare it with previous safe-biking devices they had. For all of the testing, our product performed perfectly, and the feedback was very constructive for our future development.

Finally, we looked into the prospective future of Turning Helper, and we currently expect several technical future advancements. First, the VRM motion detection system’s size needs to be decreased. Then, an online server and application is expected to be established to help consumers personalize their Turning Helpers, such as the language and display color, and to collect data and feedback from users.