PROJECT PROPOSAL

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AssistWave

Empowering Connection Through Every Gesture.

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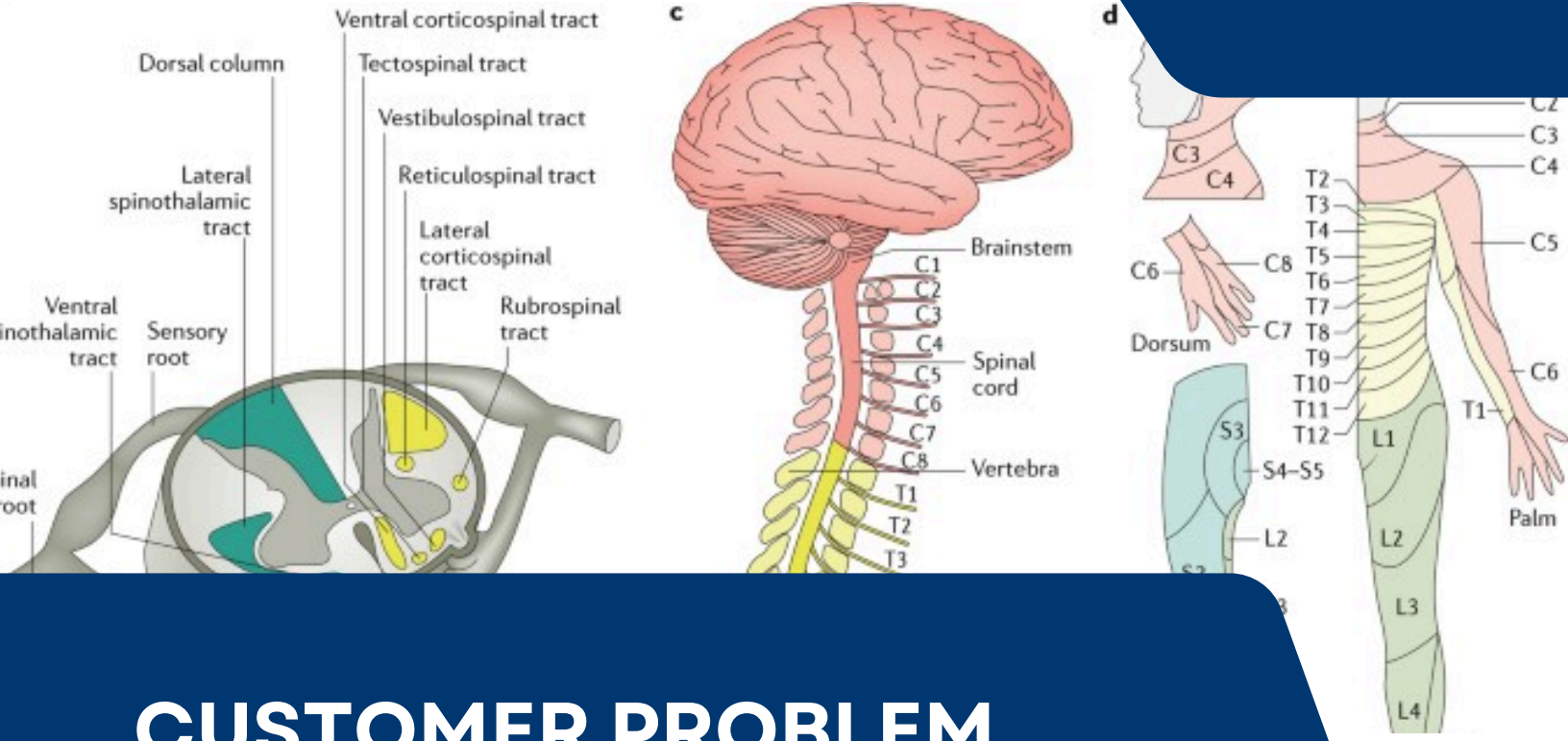
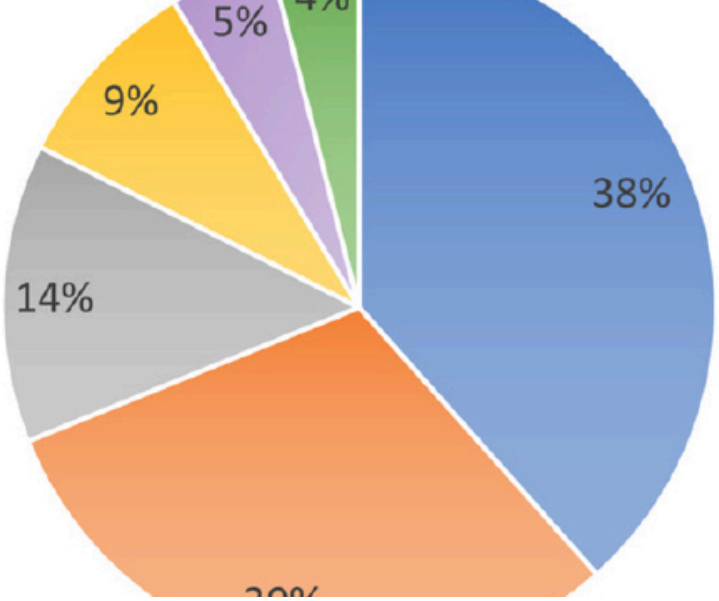


CUSTOMER PROBLEM

TRAUMATIC SPINAL CORD INJURIES (TSCI)

Traumatic spinal cord injuries (TSCI) refers to a traumatic blow to the spine which can leave one paralyzed. Many of these people need to learn how to adjust to life post TSCI. After an individual suffers from a traumatic injury, which leaves them paralyzed, their lives change, and some tasks become more complex [18]. Simply getting up to turn the lights off can become much more laborious for them to do. These tasks which one may have previously taken for granted have to be reconceptualized to match the individual's capabilities [17].



Customer **Problems**

→ **AssistWave Device**

Solution

AssistWave has devised a way to help accomplish these simple tasks by using easy hand gestures. The purpose of this device is to use simple hand gestures to control technological devices, so that the individual won't have to move to turn them off or on. This will make a person who is suffering from TISCI's life easier by reconceptualizing how they complete these tasks.

Target Audience

AssistWave's target audience are people who suffer from TSCI, specifically people who are paralyzed from the waist below. Currently in Canada, 15,533 are paralyzed from the waist below [19]. This makes it so that the target audience size is 15,533.

Initial Requirements

AssistWave Device

Functional Requirements

Technical Requirements

Safety Requirements

Functional Requirements

STM32CubeIDE and STM32 Nucleo Board

A functional requirement is the use of the STM32 Nucleo Board and STM32CubeIDE, which is a C/C++ development platform that generates and compiles code and debugs features for STM32 microcontrollers [8]. This IDE needs to be utilized to implement device configuration, external libraries, code editing, and configuring pin modes and communication settings [8]. The STM32 Nucleo Series requires 128 KB to 2 MB of flash memory and up to 640 KB of RAM, a USB connector and wiring and a supply voltage of 5 V for the AssistWave device and must operate at a frequency of up to 250 MHz [7].

AI Software (STM32 model zoo)

The artificial intelligence-based ToF network must be trained using the training script from the STM32 model zoo [6]. According to the STM32Cube.AI documentation, the STM32 model zoo is a collection of pre-trained machine-learning models [6]. Successful completion of this technical requirement means the ToF sensors effectively detect and track hand gestures as input. STM32 Cube.AI requires a flash of 27,868 bytes, RAM of about 5000 bytes, inference time of 77 µs and a closed source [6].

Functional Requirements

Continued

ToF Sensor

The ToF sensor is a major functional component that uses a 940 nm light source to illuminate an object and measure distance with a depth precision of about 0.1% [5]. A camera is not needed to collect input – but the hand-tracking software will need to consistently record the accurate real-time position of the user's hand in a cartesian coordinate system with a depth accuracy of about 1% indoors up to 60 meters [5]. Designated hand gestures will be defined to enable functions, including switching on a light, regulating a thermostat or fan and signalling caregivers for assistance from more than a meter away. For example, a thumbs-up would be used to switch on a light, a thumbs-down would be used to control the thermostat, crossed hands for the fan and an outward palm to transmit a signal to the other microcontroller.

Door Handle

Someone with a lower-body disability may find it difficult to answer the door continuously, especially if the individual lives in a home with multiple floors, and spends most of the time on a floor that isn't connected to the front door. Due to this, AssistWave plans on creating an automated door system, which allows an individual to open the front door from their own room with just a hand gesture. This function will require a servo motor driver, which typically requires 5V [3]. This value is achievable with the circuit that AssistWave is planning. A servo motor is able to rotate 360 degrees, so AssistWave plans on connecting it physically to the door handle, and rotating it until it unlocks (this depends from door to door) [3]. The angle and the voltage can both be measured when testing.

Technical Requirements

Input

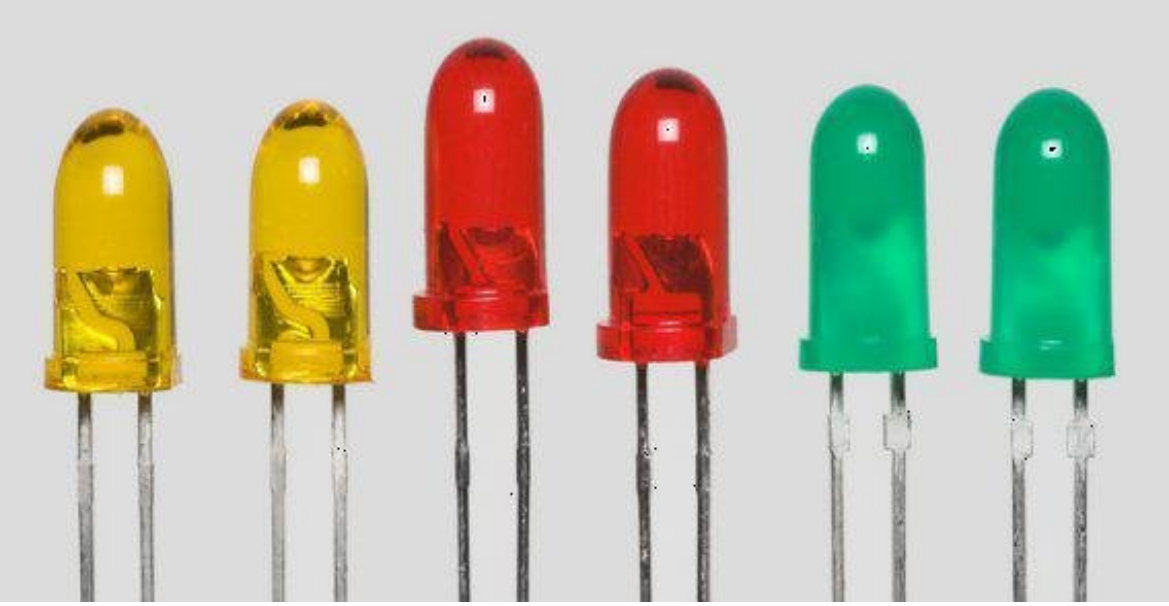
AssistWave will need to use an ST multi-zone Time-of-Flight (ToF) sensor to collect input from the user in the form of particular hand gestures. The accuracy of ToF sensors depends on how far the object is placed from the sensor. AVSystem states the sensor can achieve an accuracy of about 1% of the distance value – in other words, the ToF camera must achieve an accuracy of about 1 cm for an object 1 meter away [4]. The ToF sensor is required to operate within a 65° field of view and illuminate an area of approximately 4 by 4 cm for a distance of 1 meter [4].

Transmitting Information

The technical standards for the project also require that the **STSW-IMG035_EVK** graphical user interface can test and evaluate the hand gestures and communicate signals to the **Universal Asynchronous Receiver Transmitter** (**UART**) [11]. UART is a communication interface used for transmitting and receiving information between one microcontroller to another microcontroller over a distance of one meter or greater. As per the UART documentation provided by Arduino, AssistWave's serial UART must pass basic parameters, including a maximum baud rate of 115200 bit/s (defines the speed at which data is transmitted), a real transmission speed of 86.806 µs, a maximum data rate of around 5 Mbps, 8-bit messages (includes ASCII characters, numbers, etc), no parity and 1 stop bit [11].

Output - Light

The STM32CubeIDE program code must output at least two functions – such as switching the LED light or motor fan on and off. According to *Rise*, a typical night light uses between 2 to 7 watts of power [10]. The AssistWave device must provide incandescent lighting for the user by utilizing a 10-watt LED light bulb. Night lighting is melatonin-friendly as it improves eyesight, promotes a healthy sleep pattern and can create a comforting atmosphere, alleviating some stress for the client [10].



Output - Motor Fan

One task that AssistWave will aid the consumers with is turning on and off fans, specifically ceiling fans. The average ceiling fan requires 120V [9]. This is an extremely high voltage, which can potentially be lethal, so AssistWave will be testing this on a smaller scale with a 5V fan. This can be measured using a tachometer, which can measure how fast the fan is spinning [9]. This fan can be helpful for disabled individuals who want to turn their fans on or off without physically having to move to the location of the switch.

Safety Requirements

Addressing Safety Concerns

There may be numerous safety concerns due to the potential for data breaches, hacking into the UART and ToF systems and invading user privacy with the use of AI recognition software. As information is transmitted from one microcontroller to another, users may have privacy and ethical concerns with how information is received and transmitted to the other microcontroller. Fortunately, AssistWave will meet optimal safety standards with its built-in private and non-invasive features. According to AVSystem, the ToF sensors require no image or camera to detect user input, ensuring complete user privacy [4]. The information and technology product must be licensed as an assistive device as per the Medical Device Regulations [1] by Health Canada [2].

Principles

Ohm’s Law

Ohm’s law states that the voltage across a conductor is directly proportional to the current flowing through it, provided all other conditions remain constant.[15]

$$V = IR$$

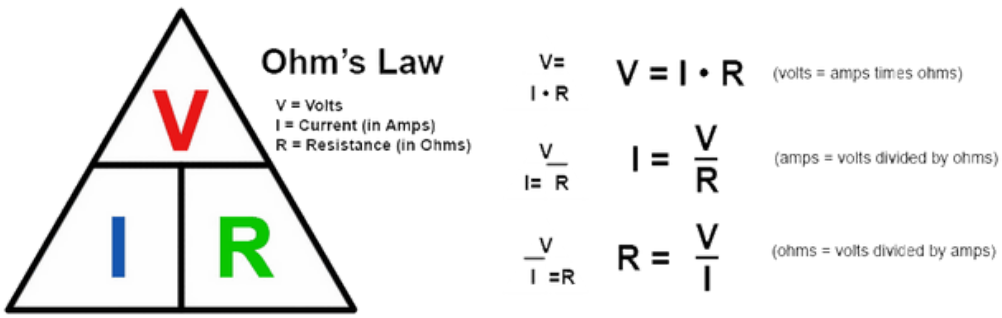
Where:

V = voltage across the circuit

I = current flowing through the circuit

R = resistance of the circuit

STM32 microcontroller applications are built on using Ohm’s Law, as it allows us to calculate the required resistance for a given voltage and desired current in the motion detection system. This calculation guarantees that the chosen resistors will adequately restrict the current to safe levels, safeguarding the STM32 microcontroller and improving the overall reliability of the motion detection alert system. [13]



Time of Flight (ToF)

Time of flight is the measurement of time taken to travel a distance to determine distance, speed, or properties of the medium. Time for a signal to reflect off an object is often measured to determine the object's location.[14]

$$t = d/v$$

where:

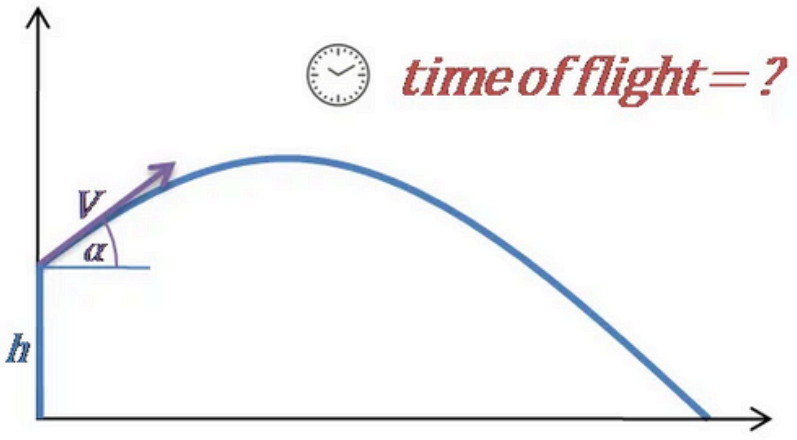
t = time of flight (sec)

d = distance the signal travels (m)

v = speed of the signal (m/sec)

(which is speed of light in air)

The STM32 microcontroller sends light signals and picks up the reflected signals. The STM32 microcontroller tracks how long it takes for the reflected light to come back, and by using the equation above, it calculates how far the object, in this case hand, is from the reflected object, and where in space is the hand. This positioning of the hand is very important, as by analyzing it we can determine whether the individual is signalling for assistance.



Displacement

Displacement is change in position of an object. This concept is crucial for calculating an object's displacement, velocity, acceleration, and to see if an object is stationary.[16]

$$\triangle s = s_f - s_i$$

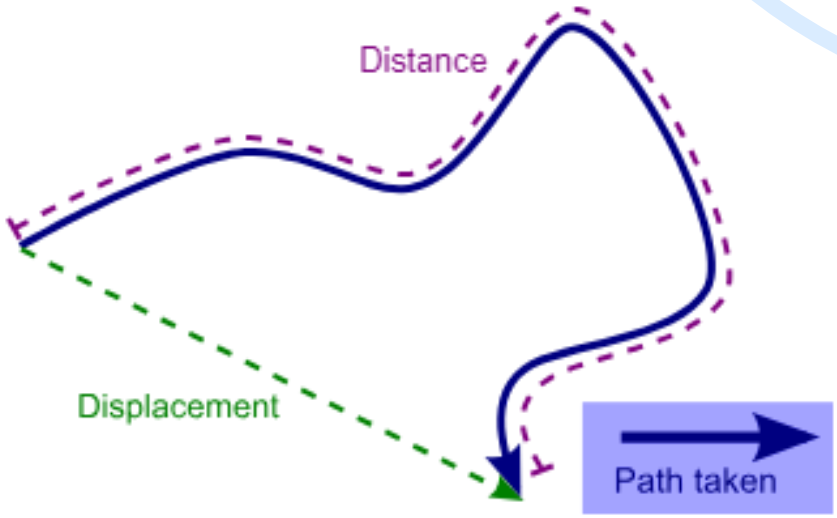
where:

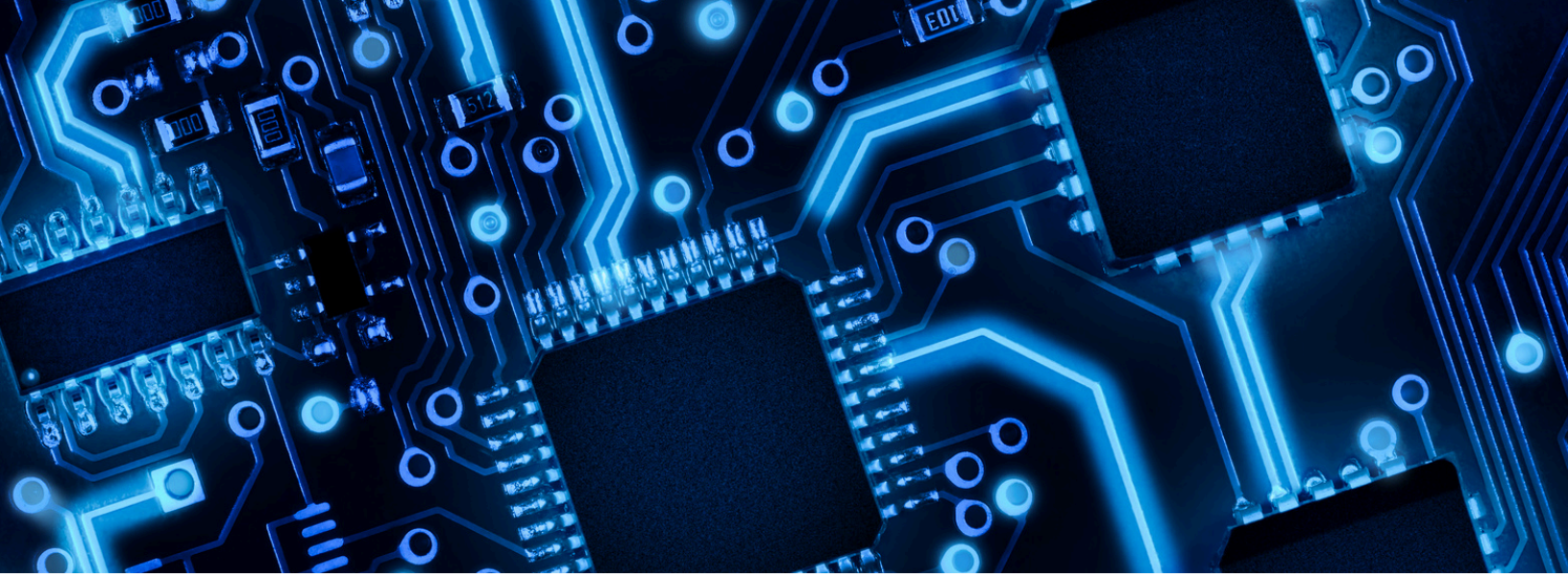
s_i = final position

s_f = initial position

Displacement measures the distance an object has travelled from its original position, which is essential for motion detection systems.

For example, when the system identifies a change in position using sensors, it calculates the displacement to assess whether the movement is significant enough to set off an alert.





AssistWave Features

In Conclusion

Solution

Due to immobilization, patients will experience difficulty with autonomously performing simple tasks. To combat these challenges, AssistWave offers hand gesture recognition software for individuals with TSCI to communicate with caregivers to support crucial activities such as eating, drinking, restrooms and emergencies within a home setting. Additional electronic aid features include sensors to detect specific hand gestures to control and communicate between light switches, thermostats and ventilation systems wired to the microcontroller board. AssistWave aims to provide a compact and user-friendly automation device to address the communication barriers experienced by paralyzed patients, so they can become more independent and take control of their lives.

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