The Puffin: A Mouth-Operated Assistive Device for People with Disabilities

In collaboration with Puffin Innovations

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Problem Statement

The goal of our Major Qualifying Project is to work with Puffin Innovations to develop a production-level prototype of the Puffin device and make both hardware and software developments to improve the user experience.
Background

- Assistive technology devices enable those with manual dexterity impairments to complete every day functions
  - Hand Exoskeleton System
  - Tongue Drive System
  - FLipMouse

- Adriana Mallozzi, an entrepreneur with cerebral palsy, founded Puffin Innovations to develop a device known as the Puffin
  - Portable, Wireless, Affordable
  - Mouthpiece mounted on a wheelchair that can be used to operate bluetooth devices
  - Won the 2015 MIT Hackathon

- Several improvements to the Puffin are needed to bring to production
  - Bluetooth enabled chip and microprocessor needed
  - Power system overhaul
  - Chassis redesign
  - Coding Improvements
Objectives

- Understand prototype created by Puffin Innovations
  - What was working, what was not working
- Improve the prototype
  - Upgrade the microcontroller and Bluetooth interface
  - Create PCB that accommodate the new platform and components
  - Redesign encasing to accommodate new additions
  - Improve the functionality and accessible design of the Puffin app
  - Find a certified battery that lasts at least 24 hours
General Architecture

- Input components: Joystick, push buttons within joystick
- Output components: Buzzer, LEDs
- Power: 3.7 V Lithium-Ion Battery which requires an external charger as the MCU’s battery charging module does not output enough current. LDO to get 3.3 V output for the MCU
- Microcontroller: STM32L476RG
- Bluetooth Module: BlueNRG-2
Hardware Implementation

- 3 in. by 2 in. PCB with SMD resistors, caps, ICs, connectors, and buzzer
- Buzzer is SD1209T3-A1 Buzzer from TDK that requires pulsed input between 1V-4V (3.3V) of frequency 2.048kHz
- Volume of the buzzer controlled by the duty cycle of a pulse from the STM32 MCU
- LEDs connected to I/O pins of the MCU and resistors that go to two connectors on the PCB
- Battery connected to the board via two connectors. An LDO is used to drop down the voltage to the 3.3 V for all circuitry
- The MCP73831 PMIC uses the 5V USB input to charge the battery. Outputs 500 mA current
- USB-UART converter IC to act as an interface between the USB and STM32 MCU
Firmware Implementation

- **Hardware + Software**
  - Microcontroller: STM32L476RG
  - Bluetooth Module: BlueNRG-2
  - IDE: STM32CubeIDE

- **Design Choices**
  - Arduino → C
  - Maintain original code structure
Companion App Implementation

The Puffin has a companion app for Android devices that allows access to a variety of features.

Features prior to project:

- View, edit, and update the Puffin’s settings via Bluetooth
- Connect to a Puffin device via Bluetooth

Added features:

- Visual and motor-skill accessibility design
  - High color contrast
  - Scaling text and buttons to maximize size
  - Clear borders around interactive elements
- File transmission
  - Send files via Bluetooth
  - Intended (not implemented) to serve firmware updates and modules to the device
- Device calibration
  - Gathers motion data from a simple task and suggests new device settings accordingly
Recommendations

- Use USB C instead of Mini-USB for faster data transfer
- Replace the QFN package for the USB-to-UART converter IC with the SSOP package to make soldering easier
- Hire professional solderers to ensure lead time for production is low
- Continue to use Lithium Ion Batteries for the device
- Implement low-computation machine learning for Android calibration
- Develop firmware modules for integration of common assistive devices
- Implement RTOS to optimize responsiveness and battery life
QUESTIONS?