Haptic Feedback for Hand-Held Injection Devices

Degree programme: BSc in Micro- and Medical Technology
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The main aim of this thesis is to investigate the possibility of the implementation of haptic feedback (vibration) as an addition to the visual, mechanical and acoustic feedback already present in the injection system. By implementing vibrations on the Smart Pilot, the device could become clearer and more intuitive by applying patterns of varying complexity during different phases of its use.

Introduction

An auto-injector is a medical device designed to deliver a single dose of liquid medication through a pre-filled syringe provided by the pharma-company. This project investigates if the implementation of haptic feedback (vibration) could improve the understanding and interaction with the device, as people are increasingly familiar with haptic feedback through everyday technology. With this goal, the development and implementation of a SmartPilot prototype incorporating haptic feedback without altering the external case design was built and used as testbench to conduct a user experience (UX) study to validate the concept.

Method

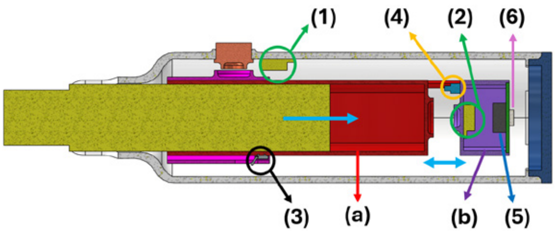
A theoretical analysis was conducted to choose the best haptic system for the project out of several options including, but not limited to piezo-electric, Eccentric Rotating Mass and Linear Resonant Actuator. To preserve the external appearance of the original case, two possible attachment points were identified to fix the vibrating system (1) or (2). A small study with eighteen participants was conducted to determine which of the actuator locations was most effective. To avoid unnecessary complexity associated with the original electronics, a simplified system was implemented, using two easier detection systems. For auto-injector detection, the lever switch was reused from the basic system (3). For injection detection, reed switches, Hall sensors and mechanical switches (4) were evaluated to detect the movement of part (a) towards part (b), caused by the pressure exerted when the user inserts the syringe into the skin. To maintain the audio and visual feedback of the basic system, the same passive buzzer (5) was used, along a simplified RGB LED system, using one high intensity LED (6) instead of six. Due to the availability of suitable libraries and functions, an Arduino microcontroller was selected to manage and power the system. Finally, a compact PCB was designed for the integration and wiring of all components inside the device. A moderator guide was developed for the UX study, outlining the test introduction, user tasks, and specific questions designed to evaluate how effectively haptic feedback aids users in understanding the system.

Results

Out of the analysis, the Linear Resonance Actuator was selected, paired with the haptic driver to control it effectively. It was preferred over the Eccentric Rotating Mass for an improved vibration precision and over piezoelectric for lower costs and power consumption. A mechanical switch was chosen for the injection detection due to its high reliability, low power consumption and the semplicity of integration. The position (1) for the vibration actuator demonstrates to be most effective in transmitting vibration to the user without affecting the syringe with accelerations between 0.9-1.45g by the actuator. The usability analysis results indicated that combining haptic and light feedback enhanced user clarity and overall device experience. However, the haptic pattern used to signal the end of injection was perceived by some users as ambiguous, unnecessary or irritating. This suggests that simplifying or modifying this specific feedback could improve the user comprehension.

Outlook

Future work could explore vibration absorption in the system to limit transmission to the needle. The SmartPilot App could be enhanced with customizable menus for selecting haptic effects in each phase. Further work should also focus on integrating the prototype into the existing device architecture.



Simplified internal view of the Smart Pilot system with auto-injector

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