

Wireless Touch Detection and Transmission System for Épée Fencing

Lisa Goliyad
Mr. Adam Kemp

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Abstract - Competitive fencing consists of three disciplines: foil, sabre, and epee. Epee has a full body target area and a button tip based scoring mechanism, where the tip must be sufficiently compressed to register a point. The current scoring system relies on a wired system with multiple components, which has many points of failure. This project aims to develop a compact wireless transmitter that plugs directly into the blade and sends a signal to an identical receiver connected to the scoring machine, eliminating extra components to reduce potential failure. Six radio modules were tested for reliability, range, speed, and size, before arriving at the current prototype, which utilizes a ATtiny85 microcontroller and a REYAX RYLR998 LoRa radio module mounted onto a custom PCB. This combination was selected particularly for its high range, even under interference, small size, and low delay. Quantitative targets include a 10-20ms response time, maximum 40x40x15mm transmitter and receiver size, minimum 36 hour battery life, and reliable transmission at 20 meters or more in high interference settings.

Index Terms - épée fencing, LoRa, touch detection, wireless scoring

INTRODUCTION

The current scoring system used in epee fencing has a central scoring machine wired to a reel box on each end of the strip. From here, the reel connects to a fencer's body cord, which runs through their jacket and sleeve and connects to their blade. While functional, this wired system has regular failures, which very often causes long delays and scoring disagreements. At large tournaments, this can largely affect the efficiency of bouts and fair results.

The goal of this project is to design and build a transmitter that plugs directly into the bell guard and wirelessly transmits a signal to an identical receiver plugged into the scoring machine. The key goals are to create a reliable, fast transmitter that closely resembles the traditional wired components, creating a seamless transition for fencers.

PROJECT BRIEF

REQUIREMENTS

For the wireless system to be considered a success, there are a number of qualitative and quantitative objectives. Quantitative objectives include an operating voltage of 2.92 V DC, a response time of 10-20ms, an attachment weight of no more than 20 grams, and an attachment that fits within a 40x40x15mm area. These are so the wireless attachment replicates the traditional wired system as closely as possible, providing a seamless transition for athletes. Other quantitative criteria are a battery life of at least 36 hours and a minimum transmission range of 20 meters in high interference conditions. These are so the transmitter and receiver are convenient to use and have little risk of causing bout delays.

Qualitative requirements include producing a functional prototype, achieving strong and secure attachment to the weapon, demonstrating adequate durability during use, ensuring comfort for the user, and allowing easy battery recharging or replacement.

OVERVIEW

A wirelessly transmitter is designed to plug directly into the bell guard socket, replacing the body cord connection. The current prototype is built around a Digispark ATtiny85 microcontroller and a REYAX RYLR998 LoRa radio module, soldered onto a custom PCB. The ATtiny85 was selected for its compact size and low power consumption. The RYLR998 LoRa module was chosen for its long range transmission capability and its operation at 915 MHz, a frequency with far less interference than the 2.4GHz band used by WiFi.

Six different radios were tested prior to the current design. These had various issues, such as a long delay, short range, large size, and inconsistency. The RYLR998 met size, power, range, and interference requirements.

LIMITATIONS

The primary hardware limitation is the size and weight constraint, set in place to replicate the current attachment configuration as closely as possible. The bell guard socket has a fixed connector, limiting how the transmitter can physically connect with the weapon. Battery capacity is constrained by the weight limit, a lighter cell means less energy storage, posing a risk to the 36 hour battery life minimum. In large venues with multiple simultaneous wireless scoring systems being used, there may be high interference, decreasing range in a way that is difficult to account for in a controlled testing environment.

EVALUATION PLAN

The process began with testing different radios for response time, transmission range with and without interference, size, and reliability. Response time was tested by sending a signal between two radio modules, and connecting the receiving end to an LED that would light up when the signal was received. No exact time measurements were taken, response time was just judged by an estimation. Transmission range was tested by setting up a transmitter which would send frequent messages to the receiver. The receiver was moved further away until the signals would stop coming through. This was tested both indoors and outdoors to observe operation in different levels of interference. Size was roughly estimated based on the size of the radio module and the maximum size of the attachment component. Reliability was measured by sending frequent transmissions in different orientations and recording if all transmissions went through.

After deciding on the REYAX RYLR998 radio module, it was paired with the ATtiny85 microcontroller. The ATtiny85 was chosen for its small size and low power consumption. The setup with the radio and the microcontroller was tested by soldering the individual components onto a PCB to function as a transmitter and attempting to send a simple signal to a RYLR998 receiver.

DEVELOPMENTAL PROCEDURES

First, characteristics of the existing body cord system were noted, such as operating voltage, size, and weight. Various radios were researched and tested by assembling test circuits and roughly measuring response time and range, and observing size and weight. The first radio tested was the SRD-05VDC-SL-C, which was eliminated due to a long response time. The next radio tested was the LTV702VC, which was also eliminated due to excessive delay. The next radio tested was the ESP01, which had a good size and low

delay, so it was further tested in a full transmitter and receiver prototype, attached to the blade. It was later rejected for range restrictions and high possible interference. The next radio module was the NRF24L01, however it was too large and was not further tested. The next radio was the ESP32 LoRa, which was too large and functioned inconsistently. The final tested radio was the REYAX RYLR998, which was determined to fit all the requirements. The ATtiny85 microcontroller was then selected to pair with the RYLR998, based on size and power consumption. A PCB layout was designed and soldered to accommodate both components within a small area. Spectrum analysis was conducted at 2.4GHz and at 915 MHz (frequency of the RYLR998) to see the difference in interference and to confirm that the radio transmission is clearly distinguishable at 915 MHz.

APPENDIX

Design and implementation of a wireless scoring system in épée fencing

DESCRIBE THE ISSUE

In fencing, every small detail can determine if you win or lose a point. With the current scoring system, with focus on épée, there are many components that, if not working properly, can stop your touch from getting registered on the scoring machine or put you at a disadvantage. Many issues are caused by the reel box. Since it is positioned at the end of the strip where people often walk, it can get unplugged quite often. Another problem is if the body cord shifts when running through your jacket, it can be uncomfortable and distracting. From personal experience, I have noticed that due to the number of components and connections, it is difficult to pinpoint exactly where the issue is in the case of a mechanical failure.

The first variation of an electronic scoring system in epee was introduced nearly a century ago. Today, although many changes have been made to the system, at its core it's similar. A scoring machine stands next to a strip, which has two wires running to each end of the strip. There, they connect to a reel box. The reel is then attached to a fencer's body cord and clipped onto the jacket. The body cord runs through the jacket and out of the fencer's glove, where it plugs into a socket inside the bell guard. Here, two small wires run through the top of the bell guard and up a groove in the blade to the tip. In the tip, there is a small spring, and a large spring, which keeps the tip up. When the tip is compressed, and the small spring touches the base, the circuit between the two wires is completed, and a light is registered on the scoring machine. While this does work most of the time, there is still some unreliability in each component, which adds up. Also, due to the size of the

springs, it is difficult to tighten them just the perfect amount, leading to variation across fencers.

This research, if successful, can replace and simplify a large part of the fencing scoring system with a simple wireless box. It can be installed on any epee, meaning you don't need to buy a whole new equipment set. Also, it is cost-efficient. It is much cheaper than the whole system or any other wireless fencing devices. This can increase reliability and comfort in fencing for people of all skill levels.

Although the system with the body cord and reel box is the only one currently accepted internationally and across all FIE (Fédération Internationale d'Escrime) tournaments, there is another design that was used at one olympic games and a few world championships before being discarded due to significant error and backlash. The design is simple, a small box attaches to the end of your body cord and sits in your back pocket. The main reason it was eventually removed from international competitions was because the signal sent out was weak, and often unreliable. Another issue was the signal interference from other wireless bouts nearby, which also made it very susceptible to someone remotely manipulating the signal from another device nearby. The third reason it was not received positively was because of the battery life. The battery, if not properly charged, could run out mid-bout and cause issues and delays. The only version of this system that is approved internationally is made by one company, and requires a technician to set up and start every bout.

A cost and space-efficient replacement to the fencing body cord and reel box can improve fencing accuracy, reliability, and comfort, without making any changes that affect a fencer's performance. If incorporated into real tournaments, it can save cost, and make events run smoother since less time will be wasted on equipment repair. Also, this system is compatible with the old, and both can be run at the same time in case of any issues.

Objectives

Quantitative

The voltage through my blade should match the correct voltage of 2.92V which I measured runs through a traditionally used blade, likely from a 3.3V battery.. This is so it can match the voltage in a traditional wired blade, allowing both to be used on the same strip.

The response time from when the button is pressed to when it lights up on the scoring machine should be approximately 14ms, but can vary from 10-20ms with a traditional blade. Similarly, only touches scored by both opponents within 40ms should count as a double touch. Past that, only a single touch should be registered. Similarly, once

a touch is shown on the scoring machine, the light should remain on for between 1-2 seconds.

The weight of the attachment should match the weight of the end of a body cord, so a fencer does not feel a difference. This should not exceed 20g, aiming for approximately 15g.

The battery life should be a minimum of 12 hours, so there is no concern of your blade turning off in the middle of a bout. However, I will use any extra room and weight I have to extend this time as long as possible.

The size limit for the box in the bell guard should be approximately 40x40x15mm, however slight variations won't cause an issue as long as they don't intrude onto the grip area.

The blade should be able to send a signal to the scoring machine within minimum 10 meters, however I will try to make this as far as possible in case anyone needs to step off the strip.

Qualitative

One qualitative object I will meet is making a functional prototype. I will test it in a bout, and see if scoring a touch will cause the scoring machine light to turn on.

Another objective is if the box holds well. I will also test this in a bout, where I do many different motions including beats and parries where you hit another blade and see if it holds well and doesn't cause any issues.

Similarly to the last one, I will also test if the box is durable. I will use the blade in rough motions, and artificially simulate use by trying to damage the blade to see if it still works and if the box does not break.

Another goal I have is to make it comfortable. I want to make sure that different fencers with slightly different grips are not affected by the box. I want to make it as similar to the traditional socket as possible to minimize discomfort.

An important objective is to make sure the battery is easy to attach and detach from the rest of the box, so you can easily replace it and take it out to charge. I will also test if this is easy to do with a glove on, in case you are in the middle of a bout.

Approach

I first plan to create a simple button connected to a small box which sends a signal when pressed, not attached to a blade yet. Following this, I will begin to transfer this design onto a functional blade. I will make sure that voltage through the blade and the response time is the same response time as a traditional weapon. Additionally, I will work on displaying the battery percentage and time remaining, as well as finding an efficient way to replace and charge the battery between use. After making a functional prototype, I will work on making the weight and size of the box in the bell guard the same size as the traditional socket. Finally, I will work on making the attachment more secure in the bell

guard, as well as making sure it is comfortable and durable, and doesn't disturb the fencer in any way.

Before creating the signal receiver, I will test the blade with my computer, where the signal will be sent. Afterwards, I plan to test the attachment in a real bout at my local fencing club. I will use the blade myself and have other people use it, to see if it is comfortable for fencers with slightly different grips.

Project duration

Timeline

I first plan to create a prototype of a button, similar to the fencing tip, which is connected to an ESP-01, and when pressed, sends out a signal. After a good prototype with an accurate voltage, I will apply the same ESP-01 system to the fencing blade, incorporating the wires that already run up the blade. Once working, my next task will be to create a case for the ESP-01 and all other components so that it can fit neatly in the bell guard and connect to the blade. I will prioritize comfort and a similar weight to the traditional bell socket. Next, I will work on making the battery easy to put in and take out to charge. Then I plan to create a signal receiver that can be attached to a scoring machine typically used for wired fencing. Once the signal receiver is working, I will test the blade in real bouts at a local fencing club. If I have time left in the year, I will work on strengthening the signal so there are no disruptions in a bout, and securing it so that no one can remotely alter the signal.

Week of:

9/1 - Article reviews
9/8 - Article reviews
9/15 - Article reviews
9/22 - Project proposal
9/29 - Project Proposal
10/6 - Project Proposal Review
10/13 - Project Proposal Review
10/20 - Final Project Proposal & Initial wired button design
10/27 - Wired button prototyping and testing
11/3 - Initial transmitter/reciever design
11/10 - transmitter/reciever prototyping and incorporation
11/17 - transmitter/reciever prototyping and incorporation, testing
11/24 - BREAK
12/1 - Transfer of transmitter design to a fencing blade
12/8 - Transfer of transmitter design to a fencing blade
12/15-12/29 - BREAK

1/5 - Preparation for research symposium
1/12 - Preparation and presenting for research symposium 1/16
1/19 - Compacting transmitter, optimizing size and weight
1/26 - Compacting transmitter, optimizing size and weight
2/2 - Compacting transmitter, optimizing size and weight
2/9 - Compacting transmitter, optimizing size and weight
2/16 - Initial design of attachment between transmitter and bell socket
2/23 - Prototyping of attachment between transmitter and bell socket
3/2 - Prototyping of attachment between transmitter and bell socket
3/9 - Compacting and containing receiver
3/16 - Compacting and containing receiver
3/23-3/30 - BREAK
4/6 - Initial design of receiver attachment
4/13 - Prototyping of receiver attachment
4/20 - Prototyping of receiver attachment
4/27 - Testing of full system
5/4 - Testing of full system
5/11 - Work on any needed design changes
5/18 - Preparation for research symposium
5/25 - Preparation and presenting for research symposium 5/29
6/1 - FINALS/TESTING WEEK

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AUTHOR INFORMATION

Lisa Goliyad, Applied Engineering Research, Princeton International School of Mathematics and Science