

CS7CS6-202526

Research and Innovation Methods

Group Innovation Report

Fencer - Pro

Team Members

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Idea Description

Our innovation idea, **Fencer-PRO**, is a **Software as a Service (SaaS) platform** that utilizes Artificial Intelligence (AI) to provide **real-time classification of fencing actions** and **decision support for Right-of-Way (RoW) calls** in sabre fencing. Using computer vision techniques (pose estimation and optical flow) with audio analysis (Zero-Crossing Rate and Spectral Centroid), **Fencer-PRO** monitors fencing actions with high precision to support referee decision-making and offer actionable and engaging insights for players, coaches and spectators.

The innovation idea **Fencer-PRO** is fundamentally an exercise in commercializing and applying the technological capabilities developed and validated within **Anna Zink's dissertation, "Assistant Referee Model for Right of Way in Sabre Fencing"**.

Fencer-PRO utilizes the technical architecture and feature extraction methodologies explored and validated in the dissertation.

- **Multimodal Feature Integration:** The core of the AI relies on combining **computer vision** and **audio analysis** to accurately identify and classify fast-paced fencing actions in real-time.
- **Pose Estimation:** The system in the dissertation uses models like **YoloV8-Pose** (balance of accuracy and efficiency) to detect and track key points on fencers' bodies.
- **Optical Flow:** This innovation is built on methods like **DualTVL1**, to analyze motion and estimate the direction and speed of movement between video frames.
- **Audio Context:** The system uses audio analysis, including features like **Zero Crossing Rate (ZCR)** and **Spectral Centroid**, to add temporal context, such as detecting the sudden onset of a metal-on-metal blade clash.

Addressing Dissertation Motivations and Challenges

Fencer-PRO directly addresses all the three main goals of this dissertation research:

Dissertation Goal	Fencer-PRO Functionality
Enhanced Referee Decision-Making	Provides an objective, unbiased AI assistance tool to refine Right-of-Way decisions and reduce the ambiguity inherent in human judgment.
Improve Athlete Training	Offers technical analysis using pose and motion data, helping coaches confirm that techniques are executed correctly and recognized as intended .
Increase Spectator Engagement	Supplies real-time insights (via an API, as preferred by media) that makes the sport easier for fans to follow by explaining complex, split-second actions.

Furthermore, the business model acknowledges the challenges identified in the original research. The dissertation noted that supervised learning models, while showing potential, suffered from **significant over-fitting**. This technical limitation means that continuous model refinement (a key cost driver) and the use of continuous validation loops (a key customer relationship strategy) are necessary for Fencer-PRO to succeed and gain the community's trust

Hypothesis Evaluation and evidence

Core Hypotheses Under Investigation

The primary goal of this research is to validate the existence and severity of key pain points within the fencing community across three major groups: Referees, Athletes-Coaches, and Audience-Broadcasters.

1. **Referee Bias and Inaccuracy:** There is a verifiable pattern of bias and inaccuracy in human referees' judgments regarding the Right-of-Way (RoW) rule.
2. **Time and Money consumption in Analysis:** The current methods for match performance analysis for players and coaches are excessively time-consuming and expensive.
3. **Audience Confusion:** The fencing audience, especially casual viewers, is often confused about the point systems, the application of RoW, and how points are attained, which hinders sports growth.

Initial Evidence collected

The team interviewed fencing practitioner *Kartik Singhal* on *October 13, 2025*, to gather evidence and identify core needs for this assignment.

Core Problems Identified

The central pain point is refereeing bias and the subjective difficulty in determining the "Right of Way" (who attacked first). An objective, frame-by-frame AI analysis will help eliminate human subjectivity and error.

Identified Needs & Opportunity Areas

1. **Maximize Training Efficiency:** A system is needed to enable simultaneous training for all participants by providing unbiased point calls, eliminating the need for a dedicated referee.
2. **Objective Training Review:** Fencers need a tool that marks attack timestamps for slow-motion review, aiding self-correction and skill growth, especially for intermediate and advanced levels.
3. **Market Considerations:** The core analysis tool is deemed most beneficial for fencers at the intermediate level and above. Pricing is currently unknown as there are no clear existing market solutions to benchmark against.

Business Canvas Model (BMC)

Business Model Canvas, CS7CS2 Phase: 1 Group: 19 Title: Fencer-Pro Date: 18-10-2025				
<p>Key Partners: Who are our key partners?</p> <ol style="list-style-type: none"> Fencing Clubs and Societies - Universities, School, Private National and International Fencing Federations - e.g: FIE (International Fencing Federation) Coaching Associations and Institutes - To use pistePRO as a training support tool- e.g., EIS (English Institute of Sport), INSEP (France), or US Olympic Training Centres Event Organisers: Companies that run fencing tournaments or multi-sport events Sport Ethics Organisations: To validate that AI decisions uphold fairness Government Innovation Bodies – e.g., Innovate UK, European Institute of Innovation & Technology (EIT), NSF (US) 	<p>Key Activities: What key activities do our PR require?</p> <ol style="list-style-type: none"> AI Development & Model Training – Continuous improvement of pose estimation, audio analysis, and decision-making algorithms. Platform Maintenance & Support – Ensuring reliable SaaS performance, updates, and user support. Customer Engagement & Co-Creation – Iterative testing with federations, clubs, and coaches to refine product accuracy and usability. Marketing & Training Programs – Promoting adoption through workshops, certification courses and community engagement initiatives <p>Key Resources: What key resources do our PR require?</p> <ol style="list-style-type: none"> AI Infrastructure – Computer vision and audio analytics for real-time RoW(Right-Of-Way) detection and performance evaluation. Cloud Infrastructure & Data Storage – Scalable servers for video processing, model training, and secure data storage. Human Expertise – Data scientists, Alengineers, UX/UI designers and support staff for development and refinement. Partnerships & Community – Federations, clubs, coaches, and media partners to provide feedback, validation and training data. 	<p>Value Propositions: What value do we delivery to the Customer?</p> <ol style="list-style-type: none"> Minimising Human Error - The platform ensures consistent and accurate calls by automating the RoW decision-making process. Scalability & Multiple Use case instances of the application - The platform can be easily deployed in various fencing environments from local clubs to professional arenas and adapting to different competition sizes and formats. Reduced Bias - The platform provides an impartial analysis of actions and removing human biases from the process in terms of fairness of performance judgement. Time efficient Performance analysis - Athletes and coaches can immediately access detailed performance stats and reducing the need for time-consuming post-match analysis. Affordable and Accessible - As a cloud-based solution, it makes advanced fencing technology accessible to a broader audience, from amateur to professional levels and without the high costs associated with traditional video review systems. 	<p>Customer Relationships: What types of relationship do our customer segments expect?</p> <ol style="list-style-type: none"> Federations / Governing Bodies - Co-creation & dedicated assistance for onboarding, rule alignment and integration of AI referee system. Fencing Clubs / Coaches / Athletes - Personalized support, feedback loops, and self-service tools for training analytics and performance insights. Media / Broadcasters - Automated API access for real-time action data and commentary integration. Cross-cutting - Continuous engagement through feedback, transparency in AI decisions and updates via subscriptions. <p>Channels: How do we reach our customer segments?</p> <ol style="list-style-type: none"> Direct Channel – Related Organizations: We sell the product directly to specific organizations like fencing associations, sports analyst groups and fencing competition organizers. Social Media and Platforms - Promote the product through social media platforms. Direct Channel - Product website: An ecommerce website developed for users to order Fencer-Pro. Marketing - Sponsoring / organizing fencing events, influencer product campaigns, TV advertisements. Billboards and team advertisements. 	<p>Customer Segments: Who are we creating value for?</p> <ol style="list-style-type: none"> Primary: Athletes - Fencer-PRO helps athletes improve with real-time analysis and insights. Referees - Fencer-PRO boosts officiating accuracy with AI-driven RoW classification. Coaches & Trainers - Fencer-PRO offers data-driven performance metrics for targeted coaching. Secondary: Event Organizers/ Tournament Hosts - Fencer-PRO reduces errors and enhances event transparency. University Sport Societies and Bodies - Fencer-PRO automates refereeing and accelerates athlete development. Sports Performance Institutes - Hosts - Fencer-PRO provides precise analysis for elite training and performance. Tertiary: Broadcasters/ Sports Media Platforms - Fencer-PRO enhances broadcasts with real-time stats and visuals. Fencing Enthusiasts - Fencer-PRO deepens fans' understanding with tactical insights and analysis.
<p>Cost Structures: What costs are required to our business model?</p> <ol style="list-style-type: none"> Product Development & Infrastructure AI model training, software development and cloud storage for video processing and reliable system performance. Human Resources & Operations Salaries for technical and support teams along with costs for maintenance, hosting and onboarding. Legal & Marketing: Investing in GDPR compliance, ethical governance, and strategic marketing/partnerships to ensure trust, credibility and community engagement. 		<p>Revenue Streams: How do we generate revenue from our business model?</p> <ol style="list-style-type: none"> Subscription & Licensing Fees From federations, clubs, and academies for official competition use and access to AI-driven training and analytics features. Event & Integration Services One-time payments from event organisers and media partners for tournament deployment, real-time data APIs and custom system integrations. Premium Add-ons Additional revenue from advanced analytics modules, cloud storage and personalized AI tuning. 		

Feasibility	- Can we deliver it?
Desirability	- Do they want it?
Viability	- Is it worth it?

Table: Legend for Business Model Canvas

Business Canvas Model (BMC) Presentation Link:

https://tcdud-my.sharepoint.com/:p:/r/personal/sdeshmuk_tcd_ie/Documents/Microsoft%20Teams%20Chat%20Files/Business%20Model%20Canvas.pptx?d=wa4cbc00910444ba79ef9b2881cabb174&csf=1&web=1&e=cuTY6w

1: Value Propositions

Value Proposition	Pain Points Addressed
Minimising Human Error	Inconsistent RoW calls .
Scalability & Multiple Use Case Instances	Limited deployment options and high entry cost of existing technology.
Reduced Bias	Perceived or actual human bias in judgment.
Time-Efficient Performance Analysis	Excessive time spent on post-match video review.
Affordable and Accessible	High cost associated with traditional video review systems and professional analytics tools.

1.1: Minimising Human Error :

Critical scoring actions in Sabre fencing often happen too fast for accurate human judgment, leading to inconsistent rulings and delays. Our automated system ensures fair, efficient reviews, preserving match integrity and reducing costs.

1.2: Scalability & Multiple Use Case Instances

Current fencing tech is costly and limited to elite venues, leaving most clubs without advanced review tools. Our cloud-based platform offers affordable, scalable performance analysis and real-time review for training, competition, and broadcasting.

1.3: Reduced Bias

Human referees can be influenced by bias or pressure, risking unfair calls and eroding trust. Our system uses objective, high-speed data to ensure consistent, impartial decisions and restore integrity to fencing.

1.4: Time Efficient Performance Analysis

Performance analysis is key to improvement, but manual video review is slow and distracts from training. Our platform automates this process, delivering fast, actionable insights for players and coaches..

1.5: Affordable and Accessible

Traditional sabre analysis is costly and inaccessible for beginners and university clubs. Our tool automates feedback, reducing reliance on expensive coaching and software. It enables affordable, self-paced learning through fast, objective video insights.

2: Customer Segments

2.1: Primary Customer Segments

Athletes: Real-time analysis and automated RoW calls help improve technique, decision-making, and track progress objectively.

Referees: Offers unbiased, real-time RoW support to boost accuracy and confidence; also useful for referee training.

Coaches & Trainers: Delivers detailed metrics for personalized feedback, progress tracking, and strategic refinement.

2.2: Secondary Customer Segments

Event Organisers / Tournament Hosts: Improves officiating accuracy and professionalism with real-time RoW decisions; scalable for any event size and enhances spectator experience with live stats and replays.

University Sport Societies and Bodies: Automates refereeing and analytics to support resource-limited clubs, boosting training efficiency and athlete development while aligning with digital transformation goals.

Sports Performance Institutes: Enables player analysis, tactical insights, and injury prevention through precise, data-driven feedback for elite athlete development.

2.3: Tertiary Segments

Broadcasters / Sports Media Platforms: Enhances fencing coverage with real-time breakdowns, RoW visuals, and match stats to boost audience engagement and broaden appeal.

Fencing Enthusiasts: Offers technical insights and data-driven analysis to deepen understanding and make the sport more engaging and educational.

3: Channels

- **Direct Sales to Organizations:** Sell directly to fencing associations, analyst groups, and competition organizers.
- **Social Media Promotion:** Use platforms to build awareness and engage potential users.
- **Ecommerce Website:** Provide a dedicated site for users to purchase Fencer-PRO directly.
- **Marketing Campaigns:** Boost visibility through event sponsorships, sports influencer partnerships, TV ads, billboards, and team promotions.

4: Customer Relationship

Fencer-PRO builds lasting user relationships by ensuring trust, satisfaction, and tailored engagement across diverse customer segments. This is key to success in high-stakes fencing environments.

1. **Federations and Governing Bodies:** Federations are primary customers responsible for implementing Fencer-PRO in official competitions. These relationships are highly consultative and co-creative. Fencer-PRO works closely with federations to align the AI system with official rules and ensures RoW decisions are consistent and transparent. Dedicated personal assistance is provided during onboarding, system setup and integration into existing competition workflows. Federations also participate in iterative testing, offering feedback that refines AI accuracy and reliability and reinforcing trust and long-term adoption.
2. **Fencing Clubs, Coaches, and Athletes:** Coaches and athletes are central to Fencer-PRO's training and performance analytics features. Relationships with this segment combine personalized support with self-service tools. Users can access intuitive dashboards to analyze footwork, lunges, and other technical movements in real time. Feedback loops allow coaches to refine AI outputs and verify that the system aligns with individual athlete needs. Personalized tutorials, webinars, and educational programs increase user proficiency and confidence in AI-assisted decisions. Subscription-based updates ensure continued value delivery, adapting to new rules or feature enhancements.
3. **Media and Broadcasters:** Media partners require automated, reliable and low-latency access to real-time action data. Fencer-PRO provides API integration for seamless inclusion in live broadcasts, commentary graphics and digital platforms.

While the relationship is less personal, clear documentation, integration guides, and optional technical support ensure consistent delivery and satisfaction. Continuous updates and feedback mechanisms allow broadcasters to suggest improvements for data presentation and usability.

4. **Community and Knowledge Sharing:** Across all customer segments, Fencer-PRO encourages community building and engagement. Online forums, workshops and user groups foster knowledge sharing and allow users to discuss AI decisions, best practices, and training insights. This nurtures a sense of belonging and trust while providing valuable feedback for product refinement.

5: Revenue Stream Components

Fencer-PRO's revenue model is designed around scalability, recurring income and value-based pricing that aligns with each customer segment's needs and willingness to pay.

1. **Subscription & Licensing Fees:** The primary source of revenue comes from federations, clubs and academies through annual licenses or tiered subscription plans. Federations pay for enterprise-level access during official competitions, while clubs and academies subscribe to the platform for training analytics, video insights and AI-assisted performance evaluation. These recurring fees could ensure cash flow and long-term engagement.
2. **Event & Integration Services:** Event organizers and media partners contribute through one-time service fees for tournament-specific deployments and API integrations. This includes setting up AI-powered scoring systems, live decision support and real-time data visualization for broadcasts. Such flexible event-based pricing helps Fencer-PRO tap into short-term, high-value contracts without long-term commitments from clients.
3. **Premium Add-ons:** Additional revenue is generated through optional features such as advanced analytics dashboards, cloud storage extensions and personalized AI model tuning. These premium offerings position Fencer-PRO not just as a tool but as an educational and professional development ecosystem within fencing.

6: Key Partners

Our key partners enable the development, validation, and adoption of the AI assistant referee in sabre fencing, providing expertise, resources, and real-world environments. Our partners can also be direct customers of our product.

1. **Fencing Clubs and Societies:** Local and national clubs that test the AI system in real match settings, offering practical feedback from fencers and referees to improve accuracy and usability.
2. **Universities and Schools:** By integrating the product into their training programs, they support beginners in learning correct techniques, help coaches train more students efficiently, and contribute to continuously improving the sport for learners at all levels.
3. **National and International Fencing Federations (e.g., FIE):** As the epitome of fencing authority, they serve as the best promoters of the technology, endorsing its

legitimacy and encouraging adoption globally. Their involvement is vital for both improving the product and fostering trust within the fencing community.

4. **Coaching Associations and Institutes (e.g., EIS, INSEP, US Olympic Training Centres):** Elite performance centres that integrate the AI referee as a coaching tool for performance analytics and referee training.
5. **Event Organisers:** Tournament and multi-sport event managers who implement and evaluate the AI system during live competitions, supporting deployment and data collection.
6. **Government Innovation Bodies (e.g., Innovate UK, EIT, NSF):** Public institutions providing R&D funding, validation support, and innovation infrastructure for scaling and compliance.

7: Key Activities

Fencer-PRO's key activities focus on building, maintaining, and improving its value propositions to deliver a high-quality, reliable, and user-focused AI platform for fencing.

1. **AI Development & Model Training** is central, involving continuous refinement of computer vision and audio algorithms. Pose estimation, optical flow, and acoustic analysis are regularly improved to ensure precise real-time RoW decisions and detailed athlete performance metrics. Ongoing training with new datasets improves the performance and adapts the system to diverse fencer styles and competition scenarios.
2. **Platform Maintenance & Support** ensures seamless SaaS performance across competitions, clubs, and media integrations. This includes software updates, bug fixes, cloud infrastructure monitoring, and responsive technical support, which together maintain system reliability and minimize downtime.
3. **Customer Engagement & Co-Creation** is another key activity. Iterative testing with federations, clubs, and coaches allows the platform to be refined according to real-world use cases. Feedback loops enable AI outputs to be validated and tailored, ensuring the platform meets the practical needs of referees and athletes while building trust and long-term adoption.
4. **Marketing** complements the technical and operational activities. The goal is to highlight the product's unique value, and build customer trust by effectively communicating how the product meets customer needs and differentiates it from competitors. Strategic campaigns could lead to conversions, and foster long-term customer loyalty.

8: Key Resources

Fencer-PRO's value propositions rely on a combination of technical, human, and relational resources that ensure accurate, reliable, and user-centric AI-driven fencing analytics.

1. **AI Infrastructure:** It is the cornerstone of the platform, leveraging advanced computer vision and audio analytics to perform **real-time Right-of-Way (RoW) detection** and detailed performance evaluation. Pose estimation, motion tracking,

and acoustic cues are integrated to provide precise, multi-modal insights for referees, coaches and athletes.

2. **Cloud Infrastructure & Data Storage:** These are essential for scalable and secure operations. High-resolution video processing, model training, and data storage require robust cloud systems capable of handling intensive computational loads while maintaining fast, low-latency access for end users. Secure storage practices ensure sensitive athlete and match data remain protected and compliant with GDPR standards.
3. **Human Expertise:** It forms a critical component with teams of data scientists, AI engineers, software developers, UX/UI designers, and support staff continuously refining the platform. Technical staff ensure models remain accurate and adaptive, while UX designers and support teams enhance usability and provide onboarding assistance.
4. **Partnerships & Community:** It provides real-world validation and critical feedback. Collaborations with federations, clubs, coaches, and media partners supply training data, test scenarios, and expert insights, ensuring the AI system meets competitive standards, aligns with official rules, and delivers meaningful value to all users. Collectively, these resources allow Fencer-PRO to maintain technological excellence while fostering trust and adoption within the fencing ecosystem.

9: Cost Structures

Fencer-PRO's cost structure focuses on balancing high technical performance with sustainable operations. The key expenses are driven by research, personnel and compliance, ensuring long-term reliability and ethical deployment.

1. **Product Development & Infrastructure:** A major share of costs arises from AI model development, software engineering and cloud infrastructure. Continuous refinement of pose estimation and audio-visual models requires GPU-based computation and secure data storage. Regular maintenance ensures reliability and scalability across devices and tournament environments.
2. **Human Resources & Operations:** Personnel costs include developers, AI specialists and customer support teams responsible for platform stability, user onboarding and updates. Operational expenses cover hosting, system monitoring and technical support to ensure uninterrupted service for competitions and training use cases.
3. **Legal and Marketing:** Fencer-PRO prioritizes robust data protection standards by investing in GDPR compliance, ethical governance and secure data management practices to uphold transparency and user trust. In parallel, marketing initiatives, strategic partnerships with federations and clubs and the development of certified training programs drive brand visibility, credibility and community engagement.

Ethics Canvas

Ethics Canvas, CS7CS2 Group 19 Title: Fencer Pro Date: 22.10.2025				
Individuals Affected: <ol style="list-style-type: none"> Beginner-level fencers - May face barriers accessing our product due to cost. Competitive fencers - Become dependent on tool for training and performance enhancement, which could affect their ability to compete if the service becomes unavailable. Referees - Depend on tool for decision making support, which could impact their judgment skills if they become over-reliant on AI assistance. Referee losing their jobs. Out of Region Users - Fencers and referees in regions where the tool isn't yet available won't be able to use it. Fencers with disabilities - Individuals with disabilities who fence, may face accessibility or inclusion challenges in using or benefiting from the tool. Opposing fencers without access - Competitors who don't use the tool may face disadvantages or inconsistent experiences during matches. Club owners - May bear additional costs for adopting the tool or risk losing members if they don't implement it. Spectators - May experience changes in how matches are presented or understood due to data driven insights or automation. 	Behavior: <ol style="list-style-type: none"> Individuals if they start to over rely on the system, tend to stick to the moves defined in the system and creativity in gameplay is reduced. Players might stick to the system for feedback and not on their own senses to develop their gameplay. This diminishes the ability to tell what is going wrong and blindly following what is right. Players might feel demotivated if they are not able to keep up with the system assigned moves which are a bit above their level. Referees become over-reliant on AI tool and lose their decision making capability. 	What can we do? <ol style="list-style-type: none"> Wrong Decision - Introduce human in the loop validation, where referees can review and override AI calls when necessary. Regularly retrain and test the model using verified match data to improve accuracy and fairness over time. Wrong Analytics - Implement continuous system calibration and feedback loops from coaches and athletes to ensure analytical outputs remain valid. Use performance benchmarking and error tracking tools to quickly identify and correct inaccuracies. Job Displacement - Position the system as a support tool that enhances, not replaces, referee and coaching expertise. Provide training programs to help officials and coaches integrate the technology effectively into their work. High Energy Consumption - Adopt energy efficient AI architectures and cloud providers that use renewable energy. Optimize data processing pipelines to reduce computational demands during both training and live analysis. 	Worldviews: <ol style="list-style-type: none"> Fencers & Coaches - May rely more on data-driven feedback, changing training culture and reducing reliance on traditional judgment. Referees - AI assistance may shift the referee's perceived authority requiring stakeholders to adapt to decisions informed jointly by human judgment and AI insights. Federations & Governing Bodies - Use of AI might shift expectations for rule enforcement and transparency and in changing governance culture. Media & Spectators - Real-time AI insights may change how audiences interpret matches with a holistic view. Unequal Access - High equipment or subscription costs may limit smaller clubs or developing regions from adopting the technology. 	Groups affected: <ol style="list-style-type: none"> Fencers (Athletes) - Can benefit from real-time feedback, but may become overly reliant on AI, reducing creativity and self-reliance. Referees - AI can aid accuracy but may lead to job displacement and over-reliance on technology, reducing their decision-making role. Coaches & Trainers - Gain performance insights, but risk losing the personal mentor-mentee relationship and reliance on traditional methods. Sports Federations & Governing Bodies - Must validate AI fairness, but may face resistance from those opposed to AI's role in officiating. Event Organizers - Benefit from reduced errors and transparency, but could face technical integration challenges. Fencing Clubs & Academies - May access valuable analytics, but face barriers in adoption due to rules, regulations, cost, and infrastructure. Spectators - Enjoy enhanced viewing with real-time data, but some may question the fairness of AI decisions. Fencers with Disabilities - Could benefit if inclusively designed, but may face exclusion if not tailored to varying abilities. Parents of Junior Fencers - May appreciate the structured environment, but could worry about over-reliance on AI at a young age. Broadcasters & Media - Enhance broadcasts with live insights, but face challenges if AI decisions conflict with narratives. Vendors & Technology Providers - Demand for infrastructure but may face ethical concerns around data privacy and misuse. Developing Regions & Smaller Clubs - May struggle with adoption due to high costs and lack of infrastructure, leading to unequal access. AI Developers & Data Scientists - Responsible for creating fair and unbiased systems, facing challenges around bias and data integrity.
Product or Service Failure: (Possible Impact due to product or Service Failure) <ol style="list-style-type: none"> Technical <ul style="list-style-type: none"> Wrong Decision: If the product makes an incorrect call, the referees or viewers might be misled, leading to unjust scoring decisions. Inaccuracy in analytics: Coaches and players may train based on false feedback, causing harm to athlete development. Human <ul style="list-style-type: none"> Over-reliance on AI - Referees might accept the AI's call without critical judgment, even if it's wrong. Misinterpretation of AI outcomes - If explanations are unclear or overly technical, human users could act incorrectly on them. Bias in data handling - Human error in labeling, training, or calibrating sensors could embed bias in the model and could affect its decisions. Ethical Concerns <ul style="list-style-type: none"> Bias - If the model performs better on certain body types, genders, or fencing styles (due to biased training data), failures might disproportionately affect some athletes. Privacy violations - Fencers' detailed motion and audio data could be leaked or misused. 	Problematic Use of Resources: <ol style="list-style-type: none"> High Energy Consumption: AI model training and real-time processing requires large amounts of compute power, increasing energy use and carbon emissions. Large-scale deployment and server operations may contribute to greater resource consumption and climate impact globally. Hardware Dependence: The need for specialized sensors or cameras could lead to higher production demands and high electronic waste. Privacy Concerns: Continuous video and audio collection may expose sensitive personal data, raising concerns about surveillance and consent. Job Displacement: Increased automation in officiating could reduce the role of human referees, impacting employment and expertise in the sport. 			

	Compliance
	Contributions
	Consequences

Table: Legend for Ethics Canvas

Ethics Canvas Presentation Link:

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AI in Ideation

AI tools played a pivotal role in the ideation process for Fencer-PRO by helping structure brainstorming sessions, refine ideas, and validate hypotheses. Tools like **Mymap.ai** organized SWOT analyses, while **ChatGPT** assisted in refining language and simplifying complex concepts. AI suggestions, such as using **motion analysis** and **pose estimation**, were critically evaluated and adjusted by the team, leading to focused solutions like real-time RoW decision-making. We explored various ideas, such as AI-driven coaching and spectator engagement, but pivoted to prioritize referee training tools after evaluating market needs. Hypotheses about **referee bias** and **performance analysis inefficiencies** were validated through both AI-driven data and real-world feedback from practitioners. This iterative process of critiquing, discussing, and refining AI-generated ideas allowed the team to shape a product that addressed key pain points in fencing officiating. The proof AI usage for this work is given in the annexure.

We have sensibly and ethically used GenAI tools to assist us with the ideation and planning of the project. It was used in the boundaries of enhancing the brainstorming and efficiency of development but never in the final decision process or in the pragmatic human reasoning used to come up with it. The main tools used are:

1. **Mymap.ai:** This was used to brainstorm and structure the SWOT analysis of our ideas as to have a better vision and deepened understanding of where our principle lies- <https://www.mymap.ai/swot-analysis-generator>
2. **ChatGPT:** As a paraphrasing tool to brush up on our grammar and to give the wordings of the documents a professional flavour. <https://chatgpt.com/>
3. **Perplexity:** We used it to understand the general issues related to refereeing and performance analysis in sabre fencing. Additionally, this was used to understand the research paper assigned to us. We also used it to summarize our meeting with Kartik (Beginner Fencer)

Overall, AI has been used to edit, restructure and polish written materials in our documents. We've used it as a creative helper and as an analytical tool to help navigate the ideation process. But rest assured, all final versions have been thoroughly reviewed and validated by our team to maintain academic integrity.

Group Work Allocation Summary

Our six-member team collaborated effectively through daily 1-hour meetings and shared Google Docs for tracking and peer review.

Using an Agile-inspired iterative approach, we brainstormed ideas, developed the Business and Ethics Canvases, conducted an interview with a fencing society member and refined our final deliverable for coherence and quality. Leadership was shared naturally, ensuring balanced participation and accountability.

Deliverable	Task/Component	Contributor(s)
Innovation Description	Innovation Description (Content)	Akhil Elango, Sai Eeshwar Divaakar, Saurabh Deshmukh
	Hypothesis Evaluation and Evidence	Akhil Elango, Sai Eeshwar Divaakar
Business Model Canvas	Value Propositions	Akhil Elango, Sai Eeshwar Divaakar
	Key Partners	Niket Ghai, Navina Ganapathy Amuthan
	Customer Segments	Saurabh Deshmukh, Parth Deshmukh
	Customer Relationships	Niket Ghai, Navina Ganapathy Amuthan
	Key Activities	Entire Group
	Key Resources	Entire Group
	Cost Structure	Entire Group
	Revenue Streams	Entire Group
	Channels	Parth Deshmukh
Ethics Canvas	Worldviews	Navina Ganapathy Amuthan
	Product/Service Failure, Problematic Use of Resources, What Can We Do?	Sai Eeshwar Divaakar, Akhil Elango
	Individuals Affected	Niket Ghai
	Behaviour & Relations	Parth Deshmukh
	Groups Affected	Saurabh Deshmukh
	Group Conflicts	Navina Ganapathy Amuthan
Documentation & Formatting	Formatting and Colour Coding	Niket Ghai, Saurabh Deshmukh
	Report Documentation	Collective Work by the entire Team

Appendix

Some of the AI Prompts used:

1. Understanding Business Canvas:

- a. This is a business Canvas (see attached image) I do not understand the terms and how they are connected to each other. Explain each term and use an example to explain the terms that play a role in your example. Explain in simple terms and in detail

2. Understanding Fencing and its Market.

- a. What is sabre fencing and how popular is it? - Which countries is the sport popular - On average how many people are into fencings i.e. fencing playing population - World renowned competitions and viewing numbers? - Is it played in the Olympics - Basic Rules - Issues with refereeing the game i.e. what are the most common occurring issues related to refereeing and at what level i.e. at the lowest level what the common issues and at the highest level what are the issues.

- b. Currently are there the following things in fencing: - Using Automated systems or AI for refereeing in fencing matches like how it is happening in Tennis Grand Slams - Are there any tools or products that analyse the performance of a player and give insights on the players performance that can improve the player's performance and highlight his/her mistakes - If yes to any one of the above, provide the cost for such tools and how widely is it used and at what level

- i. Response: Sabre fencing enjoys significant popularity in several countries, particularly in Europe and Asia. According to a Reddit discussion, Italy and China are among the countries where fencing is most popular Reddit. Other nations with strong fencing traditions include France, Russia, Hungary, South Korea, the United States, Germany, China, Poland, Ukraine, and Japan SFactive.
- ii. While specific global participation numbers are challenging to ascertain, fencing has a dedicated following. For instance, USA Fencing, the national governing body in the United States, reported approximately 16,000 registered fencers as of early 2021 Academy of Fencing Masters. This figure underscores the sport's presence, though it may not fully capture global participation.
- iii. 🏆 Major Competitions and Viewership
- iv. Sabre fencing is featured in several prestigious competitions:
- v. Olympic Games: Sabre fencing has been a part of the Summer Olympics since 1896. In the 2024 Paris Olympics, the men's sabre event saw 34 competitors from 18 nations, with South Korea's Oh Sang-uk winning gold Wikipedia.

- vi. World Championships: The Fencing World Championships are held annually, showcasing top-tier sabre fencing talent. In 2023, the Championships achieved unprecedented visibility, with all nine days sold out and extensive global TV coverage SVG Europe.
- vii. Continental Championships: Regional competitions like the European and Asian Championships also feature sabre events, contributing to the sport's global reach.
- viii. While exact viewership numbers can vary, major events like the Olympics and World Championships attract millions of viewers worldwide, reflecting the sport's international appeal.
- ix. 🏅 Olympic Status: Yes, sabre fencing is an Olympic sport. It has been part of the Summer Olympics since the inaugural modern Games in 1896. The 2024 Paris Olympics continued this tradition, featuring both individual and team sabre events for men and women Wikipedia.
- x. 🗡️ Basic Rules of Sabre Fencing. In sabre fencing:
- xi. Target Area: The valid target includes the torso, arms, and head.
- xii. Scoring: Points are scored by making contact with the opponent using the edge of the blade.
- xiii. Right of Way: If both fencers land a touch simultaneously, the referee determines who receives the point based on who initiated the attack.
- xiv. Match Format: Bouts are typically fought to 15 points, with the first to reach that score winning the match.
- xv. 🚫 Refereeing Challenges
- xvi. Refereeing in sabre fencing presents unique challenges due to the sport's speed and complexity:
- xvii. Determining Right of Way: In fast-paced exchanges, it can be difficult for referees to ascertain which fencer had the attacking initiative, leading to potential disputes over points USA Fencing.
- xviii. Simultaneous Actions: When both fencers land a touch at the same time, the referee must quickly assess who had the right of way, which can be challenging in high-speed bouts.
- xix. Consistency Across Levels: At lower levels, referees may lack experience, leading to inconsistent calls. At higher levels, the pressure of high-stakes competition can affect decision-making.
- xx. These challenges highlight the need for experienced referees and clear guidelines to ensure fair play and maintain the integrity of the sport.

C. Explain Right-of-Way (ROW) to me in layman terms.

- d. Currently are there the following things in fencing: - Using Automated systems or AI for refereeing in fencing matches like how it is happening in Tennis Grand Slams - Are there any tools or products that analyse the performance of a player and give insights on the players performance that can improve the player's performance and highlight his/her mistakes - If yes to any one of the above, provide the cost for such tools and how widely is it used and at what level
- e. Currently how is the player's performance analyzed i.e. if the tool is not being used. What are the drawbacks of the current process?
- f. Traditionally how are match footage reviewed for Sabre fencing by coaches and are there any existing tools?
- g. Traditionally how are match footage reviewed for Sabre fencing by coaches and are there any existing tools?
- h. if yes what is the pricing of such tools - high, medium or low
- i. How accessible are coaches for fencing by let's say for beginners and not very wealthy people