SMART WEARABLES FOR BOXING JUDGING

HÄMEEN AMMATTIKORKEAKOULU
HÄME UNIVERSITY OF APPLIED SCIENCES

Ylemmän ammattikorkeakoulun opinnäytetyö

Tietojohtaminen ja älykkäät palvelut, Visamäki

Kevät 2022

Jani Rauma

HAMK
HÄMEEN AMMATTIKORKEAKOULU
HÄME UNIVERSITY OF APPLIED SCIENCES

Tietojohtaminen ja älykkäät palvelut — Tiivistelmä

Kampus

Tekijä Jani Rauma — Vuosi 2022

Työn nimi Smart wearables for boxing judging

Ohjaajat Kimmo Vänni

TIIVISTELMÄ

Työn tarkoituksena on suunnitella nyrkkeilyotteluiden arvosteluun sopivaa lisäjärjestelmää, joka perustuu älytekstiilien hyödyntämiseen. Työn tavoitteena on määritellä järjestelmälaajennuksen elementit ja järjestelmän teoreettinen malli. Työn tuloksena muodostaa ymmärrettävä kuva nyrkkeilyn arvosteluna käytettävästä järjestelmälaajennuksesta. Lisäjärjestelmä liittyy uutena komponenttina nyrkkeilyottelun pistelaskujärjestelmään. Tässä työssä taustatietona on käytetty miekkailua, jolla on vanhat perinteet elektronisen pistelaskun osalta sekä taekwondoa, joka edustaa modernia sensoriteknologiaa. Älytekstiilien ja teknologian hyväksikäyttö arvostelussa on nyrkkeilyn kehityksen sekä statuksen säilyttämiseksi olympialajina lähes välttämätöntä.

Työn keskeinen sisältö kuvaa pistelaskujärjestelmää mallintamiskielillä, sekä esittelee päälle puettavan anturitekniikan vaatimuksia tuotettavan datan osalta. Työssä kuvataan pistejärjestelmän komponenttia UML-mallinnuskielellä, sekä määritellään päälle puettavan teknologia tuottamaa dataa. Tulokset esitellään järjestelmäkomponentteina. Johtopäätösosiossa esitellään yhteenveto kokonaisuudesta, miten dataa voidaan hyödyntää eri sidosryhmien välillä.

Työn toimeksiantajana toimii IBA (International Boxing Association) valmennuskomissio.

Avainsanat Tietämyksenhallinta, sensoriverkot, kuvauskielet, älyvaatteet

Sivut 43 sivua ja liitteet 1.sivu

HAMK
HÄMEEN AMMATTIKORKEAKOULU
HÄME UNIVERSITY OF APPLIED SCIENCES

Tietojohtaminen ja älykkäät palvelut
Visamäki, Hämeenlinna

Abstract

Author Jani Rauma

Year 2022

Subject Smart wearables for boxing judging

Supervisors Kimmo Vänni

ABSTRACT

The thesis describes an additional system suitable for the evaluation of boxing, which uses smart textiles as a data source. The aim of the work is to form a comprehensible picture of the system extension used as a judgement of boxing. This is described as the components of a scoring system that analyzes an ongoing boxing match. Fencing, which has a long tradition of electronic scoring, has been used as background information as well as taekwondo, which represents modern technology. The use of smart textiles and technology in judgement is almost essential to maintaining the development and a status of boxing as an Olympic sport.

The main content describes the scoring system in modeling languages, and presents the requirements of wearable sensor technology for the data to be produced. The thesis describes the component of the points system in the UML modeling language, and defines the data produced by the wearable technology. The results are presented as system components. The concluding section provides a summary of how the data can be utilized in different stakeholders.

The work is done for the IBA (International Boxing Association) coaches committee.

.

Keywords Leading by knowledge, sensor networks, modelling languages, smart textiles.
Pages 43 pages and appendicle 1. page

Table of contents

FIGURES AND TABLES

Attachments

1 Purpose

This work aims to improve methods for judging boxing bouts, and find a clear winner of the bout. Analysis should be done using technical systems such as smart wearables and scoring system. The definition of the supportive system is divided into two sub-categories, the first part defines a model with a suitable method for abstracting the system and the second part analyzes smart wearables and data they should produce by user cases.

1.1 Boxing as a sport and introduction to scoring.

Boxing is a sport that could be defined as attacking defence (Hauser,T. et al., 2021). Boxing as a sport has a long history from ancient greek to pugilists in Britain in the late 17th century, where it started to develop. Rules started to develop and change boxing to a modern way in the 19th century. Rules defined the ring, knockouts, and illegal activities such as spitting, biting, wrestling or low blows below the beltline to protect boxers (Hauser,T. et al., 2021). Rules that defined types of equipment to protect boxers started in the early 20th century. Rules that are used in Olympic games are defined by Association Internationale de Boxe Amateur (AIBA), founded in 1946 (IBA, 2021) on December 2021, AIBA decided to change its name to International Boxing Association (IBA).

A boxer wears pair of padded gloves 10 Oz during the bout below 67 Kg weight categories, and 12 Oz Gloves in 67 Kg and above categories.

According to women's rule, gloves are 10 Oz for all weight categories, and also boxing helmets are mandatory. Bandages are a must, and there are the rules about material and length. Shorts and skirt definitions contain a beltline, and the boxing rules forbid to aim the

blow under a beltline whereas it is legal to punch to the beltline. The boxing vest is needed for Olympic style boxers. Gumshield also has a standard which defines that it may not contain any red or amber colour on it (IBA, 2021,p. 82).

Regarding the elite boxers, at the age between 19 and 40 years, a bout consists of threerounds, each lasting three minutes and one minute break between the rounds. The referee's most important task is to protect the boxer's health. The secondary task is to keep control in the field of play. It is good to keep in mind that the boxers may end their careers with injuries if the referees fail. The referee should not have a prominent visible role but should still keep a reasonable control of the bout.

1.2 Judging the bouts

Judging is divided into three main categories. As a result of judging, the points are given to both boxers after each round. Scores are given on a 7-10 scale for both boxers, and the winner of a round always gets 10 points and the loser gets points from 7 to 9.
Typically points 10-9 are called as a close round which means a case where boxers are almost equal to punches and techniques and competitiveness. Typically winners are concluded by a number of good quality blows on a target area, a bit more attacking, defencing or controlling and not having significant issues with intentional and non-intentional fouls (IBA, 2021,pp. 44-46).
The 10-8 round is called a clear round for the boxer to be a clear winner in all observed areas, where as points 10-7 is regarded as total dominance, and the referee should often stop the bout to avoid injuries before the round ends (IBA, 2021, p. 45). Total dominance in final results is rarely seen.

Attachment 1 presents a boxing scoring card used in competitions, if a computer system fails or are not in use.

The referee should give soft cautions by talking to the boxers during the round, for example, saying: "RED NO HOLDING". If a fault is severe, the referee might interrupt the bout by saying: "STOP," then using verbal commands and shoving correct hand signals(IBA, 2019).

Warnings should be given in a case of serious intentional failure, for example, hitting on the neck area. Warned boxers are deducted by one point on total scores of the round by a system or a supervisor. Boxers will be disqualified on three warnings (IBA, 2021).

1.3 Observing quality blows in target area

The most significant factor on scoring is to evaluate quality blows on the target area. The target area is defined in front of the body, from head to beltline (Figure 1). Quality means that blows are landed using knuckles and having a good amount of force. Hard punches have more weight on scoring than soft punches.(IBA, 2019, p. 31) .

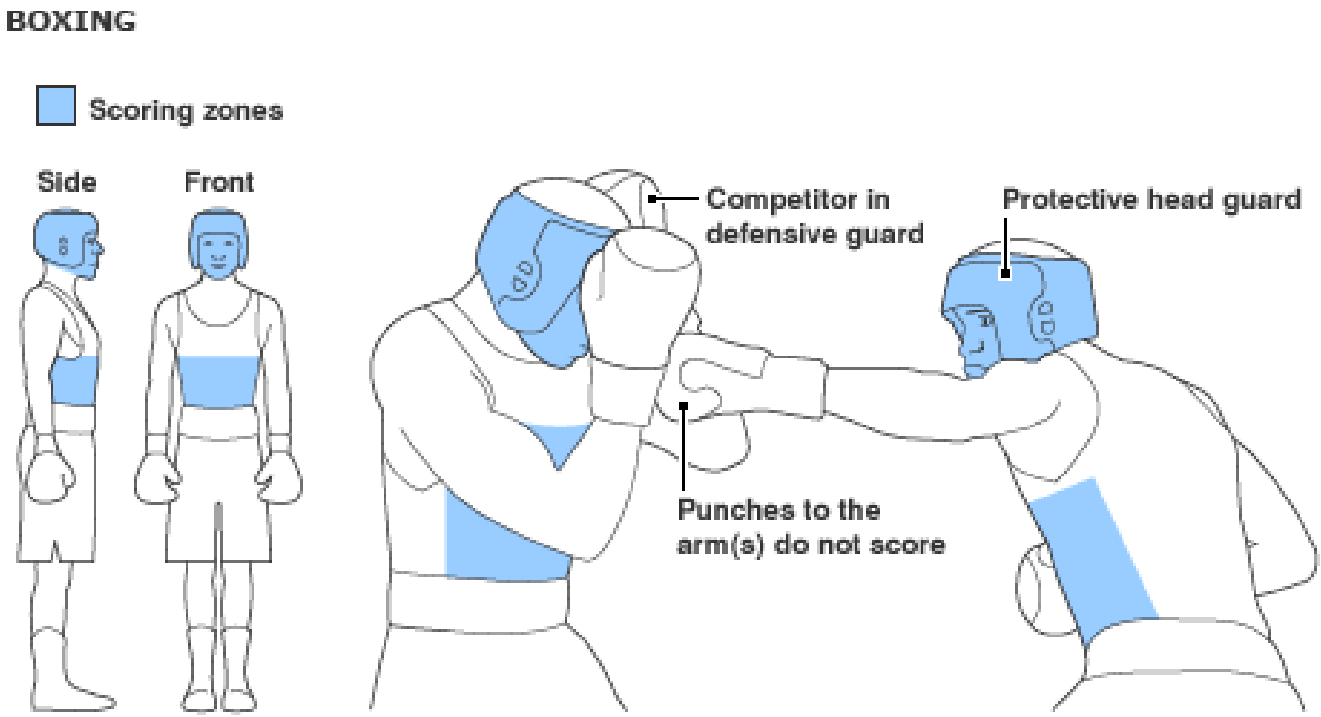


Figure 1 Scoring area (Edward, 2006)

The winner of a round is the boxer who meets the criteria better. If the quantity or quality of hits could not be observed, for example both boxers had many blows that could not be counted, then the secondary criteria should be used for finding the clear winner of the round.

1.3.1 Domination of the bout

The secondary criteria of the winner are used when judges cannot see or count the blows. In close fights, boxers throw punches, and it is hard to count blows for both boxers, especially when there is a need to see the quality of blows, such as knuckles versus slapping or the area where blows are landing.

On defense, such as hitting the opponent on gloves or number of blows are even,

The judges should decide which boxer controls the bout by making an attack or defending effectively against an opponent's attacks. A boxer who controls the ring or defends effectively is considered as a dominant boxer (IBA, 2019, p. 31)

1.3.2 Competitiveness of the bout

The last criteria that are used to choose the winner are competitiveness which is defined as a boxer's strong will to be the winner. If the boxer loses two rounds by 10-9 and in the last round the boxer wins by scores 8-10, the boxer might be considered the winner of the bout by competitiveness. The same applies if the boxer wins two rounds and is exhausted in the third round. A winning boxer shows a stronger will to win in the last round (IBA, 2019, p. 31). In case of not possible to analyze the quantity or quality of blows the secondary criteria may help to find a winner of the round.

1.4 Narrowing the problem

The highest criteria are that the judges see the blows. They are sitting and focusing on the bout. All the criteria should be remembered and the audience should be ignored when judging who is controlling a bout. The judge must see both the legal blows that landed on the knuckles and the target area. The judge cannot see blows if the boxer's back is on against visibility or the referee is in front of the boxers.

Figure 2. Legal blow?(Herbert, R., 2012), CC BY-NC-SA 2.0

As Figure 2 shows, blue might get a legal blow on the red boxer target area, but it is impossible to say whether it is done with knuckles on that angle. The evident situation is on the red boxer, who is throwing a punch by slapping instead of using knuckles.

In general, the judge decides the right winner of a round by the difference of 4-5 legal blows that meet the criteria. Blows need to fulfill quality criteria and must not contain slapping or a blow aimed at protection or out of the target area (head and front of the body).

2 Wearables in sports

Wearables could be defined as clothes or smart equipment worn close to the body. Wearables may be connected to the internet through an application or used as a simple data logger that collects data for a later analysis. The analysis could be done on the cloud, mobile application or edge computing (analysed at the source before sending).
A good example is a heart rate monitoring watch with location and altitude information. Data could be used, for example, to analyse the load of exercise. The wearable could also measure temperature, location, heart rate, quantity and quality of perspiration (Swan, 2012).

In sports, measurements of perspiration, body temperature and heart rate are quite easy to monitor. Monitoring the quantity of lactic acid content could be done by analysing tears, sweat or blood (Alam et al., 2018).

2.1 Coaching with wearables

Measuring athletes during an exercise or a rest period could report how well recovery is succeeded. For example during training, measuring heart rate at load, breath for analysing VO2max, or acid resistance of lactic acid can be used. Sports coaches are nowadays exploiting knowledge management more that before. Instead of measuring physical condition in the laboratory using different analyses, smart wearables may offer the same option during exercise in future.

Inertia sensors are accurate and could store or send data directly to devices for analysis. Cheap and common technology makes possible to add sensors to shoes, head guards or gloves. Those sensors could detect inertia data about the head movement, for example, head impacts in rugby games (Wu et al., 2016). In combat sports, wearables detect and analyse data of impacts, and the aim is to measure of a risk getting a mild Traumatic Brain Injury (mTBI) (Rahaman et al., 2020).

Inertia data could be a support to analyse e.g., golf swings. The analysis is done by using an inertia sensor located on the player's glove (Naruo et al., 2013).

Currently, there are a lot of technologies available, and the use of smart wearables among athletes is getting more common. Studies have reported that Millenials (born after 2000) are consuming wearables for functional and social factors in daily basis activities (Blazquez et al., 2020, p. 343).

Wearable technology is most commonly used as a wristband such as a watch which measures location, heart rate, and quality of sleep. There are applications linked to types of equipment where it is possible to set daily targets of steps, activity, sleep and calories burned.

2.2 Wearables for professionals

Among professional workers e.g., firefighters, wearables can be used for measuring a body temperature or any vital signs (Chong, 2014). A modern wristband can also detect sweat. It could tell the user's blood glucose level without taking samples from blood (Rodin et al., 2019, p. 7). Methods to measure are getting more accurate and offer many applications for the healthcare sector.

Firefighters have to work in extreme temperatures and sometimes in toxic environments. If measuring and showing data from oxygen supplies, sweat or heart rate, it is possible to recover enough and avoid health issues while working (Chong, 2014). In sum, smart wearables may change the way of controlling and guiding professionals in disasters.

3 Sports with wearables to analyse results

This chapter describe how sports like Fencing and Taekwondo use wearables during competition and assist to judge the bout's winner. Those examples use wearables to analyse results for the winner.

3.1 The Fencing

The Fencing, or called it a sword fighting. Three types of weapons are used in competitions Epee, Foil and Sabre. Rules regarding the types of Fencing differ mainly regarding the target area of the fencer -size, and handle of the sword. Fencing has been present in the modern Olympic Games since 1896. Fencing is one of the earliest sports that used electronic devices for scoring, system introduced in 1933 (Swiss timing, n.d.-b).
One touch is one point, and the first fencer superior to 15 points difference wins.
There are many similarities to boxing, such as attacking and defending. The stance of fencers is typically opposite to boxer, using a stronger hand as a front (FIE, 2021, p. 14).
Fencing uses electrical recording equipment to show touches and marking light indicates hits. Sword is connected to the scoring system with wire, and it has a spring-loaded end to register touches. The conductive jacket and helmet are connected. All of the pieces of equipment are connected to the scoring system. Pieces of equipment of a fencer are checked 30 minutes before the bout and the FIE logo is noticed to ensure that they are valid for bouts (FIE, 2021, p. 23).

An important part of using electrical pieces of equipment is to ensure that they function correctly. There are guidelines to analyse and calibrate pieces of equipment. The pieces of equipment and technology used are quite simple. The spring-loaded tip at the end of the sword measures touches with force. The fencer's position should not have hands in front of the target area, making it easier to analyze bouts electronically (FIE, 2021, p. 32).

As said fencing and boxing have similarities between. However, the movement of fighters, protective clothing and stance are different. It still shows that wearables are playing an important role in fast-paced combat sports to find the correct winner of the bout.

3.2 The Taekwondo

Taekwondo as a sport is more comparable to boxing than fencing and it introduces modern types of equipment for scoring the bout. Martial art as taekwondo is a series of punches, kicks and defending without a weapon (World of Taekwondo, n.d.). Taekwondo community has developed a digital scoring system to analyze fast-paced bouts.
High-speed kicks are almost impossible to see in taekwondo, and a wireless system introduces a new scoring method.
Taekwondo has been demonstrated for the Olympic games in 1988 Seoul and 1992 Barcelona, and accepted the first time as official Olympic Sport in Sydney 2000 (World of Taekwondo, n.d.).

Taekwondo uses a point system that gives different points for styles of touches (World of Taekwondo, n.d., p. 30). See Table 1.
Table 1. Taekwondo scoring

Type of touch	**Points awarded**
Punch to trunk protection	1 point
kick to the trunk protector	2 points
kick to the head	3 points
kick to the trunk with rotation	4 points
kick to the head with rotation	5 points

3.2.1 The scoring system

The scoring system consists of sensors in foot protectors, pressure sensing trunk protectors and head guards. The equipment sends data to the scoring system using wireless technology. The wearables could measure punches and kicks with rotation for different scoring.

The referee ensures no violation of the rules or stops before injuries may happen. Protectors are bigger to protect fighters against kicks force. The head guard are used in all competitions, both men's and women's elite bouts. From a system point of view, it is well developed for this sport and it should point out the correct winner of the bout during the competition.

4 Research methods

The study was a theoretical and a practice–based development work which aimed at suggesting the new model for using smart wearables in the boxing scoring. The study materials consisted of the literature search and interviews of stakeholders who were involved in judging, coaching and managing boxing. The study was explorative, and it tried to understand what elements would be needed for creating the new scoring system. The research questions were the following: 1) what are the limitations of the current scoring system, 2) what elements and technology are needed for creating the smart system, 3) which data is needed and how it may flow in the system.

5 New system definition for boxing scoring

System definition is divided by Unified Modelling Language definitions (UML-definition)

and user cases. It covers the theoretical model of the scoring system, the definition of a radio interface and boxing wearables with data they should provide for the scoring system.

UML is used as a definition language for the system to visualise operations, and the following three main styles are represented:
1) Use cases modelled with UML (Swain, 2020).
2) Explaining data flow with sequence diagrams should overview logical steps during one bout (Rumpe, 2016, pp. 191–195)
3) Explaining types of equipment and data, they produce with class diagram (Rumpe, 2016, pp. 13–17).

Use cases define a way of use and represent the user view of the system definition. Furthermore, the sequence diagram explains a boxing bout and three rounds, and the class diagram explains components and their attributes.

A scoring system is an independent system or a component that could be added to the current or future scoring system as a component. The way it is used is not covered, but it should point clearly to the winner of each round.

5.1 System way of thinking

Boxing has three three-minute rounds, and a bout could end by referee Stop the Contest (RSC) or by injuries RSC-I. Depending on the situation, points may be considered to choose a winner.
Supposed that the referee disqualifies or abandons the boxer during the bout, the boxer's points are not scored (IBA, 2019).

The boxing system marks points on each round, and a glove recognises the type of punch; to further analyse if that is hit or miss and the opponent's wearables should tell the exact point of contact.

The operator should first start the bout, then start a three-minute round and at the end of the round, stop the rounds 1 to 3 for counting points and start a new round.
Finally, stop the bout and calculate the total point with a possible deduction from warnings.

5.2 UML use case diagram

Use case diagram in UML (Unified Modelling Language) describes the behavioral system model (Swain, 2020). It is used to simplify tasks that the system does. Actors in the model are the scoring system operator and the boxers. This model does not cover warnings or many ways to stop the contest, simply focusing on counting blows on the target area.

The scoring system has an actor called the scoring system operator. Responsibilities are 1) to start the bout and 2) start and stop the rounds 1 to 3 and 3) then stop bout.

Other actors are both boxers in red and blue corners. After the bout starts, the system will analyse blows. If it marks, i.e., hit it; it checks that on a timeline an opponent’s wearable register a hit and reports That it was a legal blow. If the opponent's wearables such as a vest, a head guard or a gumshield do not show a blow within the narrow timeframe, 200ms, no-hit was landed on the target area. Then there is no point for scoring, and the blow is marked as a miss.

Hits are registered, and possible values contain timeofBlow () time, areaofBlow () area, typeofBlow () type and whoBlowed (), indicating which boxer made a blow. If it scores, then the correct boxer is added with 1 (one) point. The naming of the functions is here for an example.

The system could also measure the impact time and measure that blows on the target area are done with knuckles to ensure a legal blow. Interesting is also a possible measurement of pressure on knuckle area of gloves or a same measurement by inertia sensors to analyse force of a blow. The rules above are easier to explain with the model. Below a Figure 3 presents a simplified use case diagram, modelled as the actor's choices: the scoring system operator and boxers in the blue and red corners. Use cases are procedures to start and stop,

and as analysed, boxers produce data from wearables to be analysed and scored. This use case is just simply a model. There is a need for redesigning if a system is integrated into the current system or expanded with video recording systems for analysing and marking the blows on a video timeline. It defines the functionality and could be used to analyse statistical data from bouts after a competition day. The reason for an analyse could be the team protesting against the results, and then the jury will review the video, and the scoring system is highlighting punches that are registered with a clear colour and a number. The system should use RestAPI interfaces to transfer data between subsystems like Video Displays, Scoring systems or Online analytics, for example, showing the boxer's statistics before and during the bout.

With REST API, it is possible to add interfaces to the scoring system and make it easy to use and share data with other systems. Then it should be possible to describe available resources by use of the HTTP protocol (Surwase, 2016).

REST API methods that could be used are GET, POST and DELETE (Surwase, 2016). GET is to ask for results or other information. A POST could be used if defined; for example, adding markers of blows on the video recording system and DELETE should be used carefully but still helpful in changing weights, names, or any boxer data.

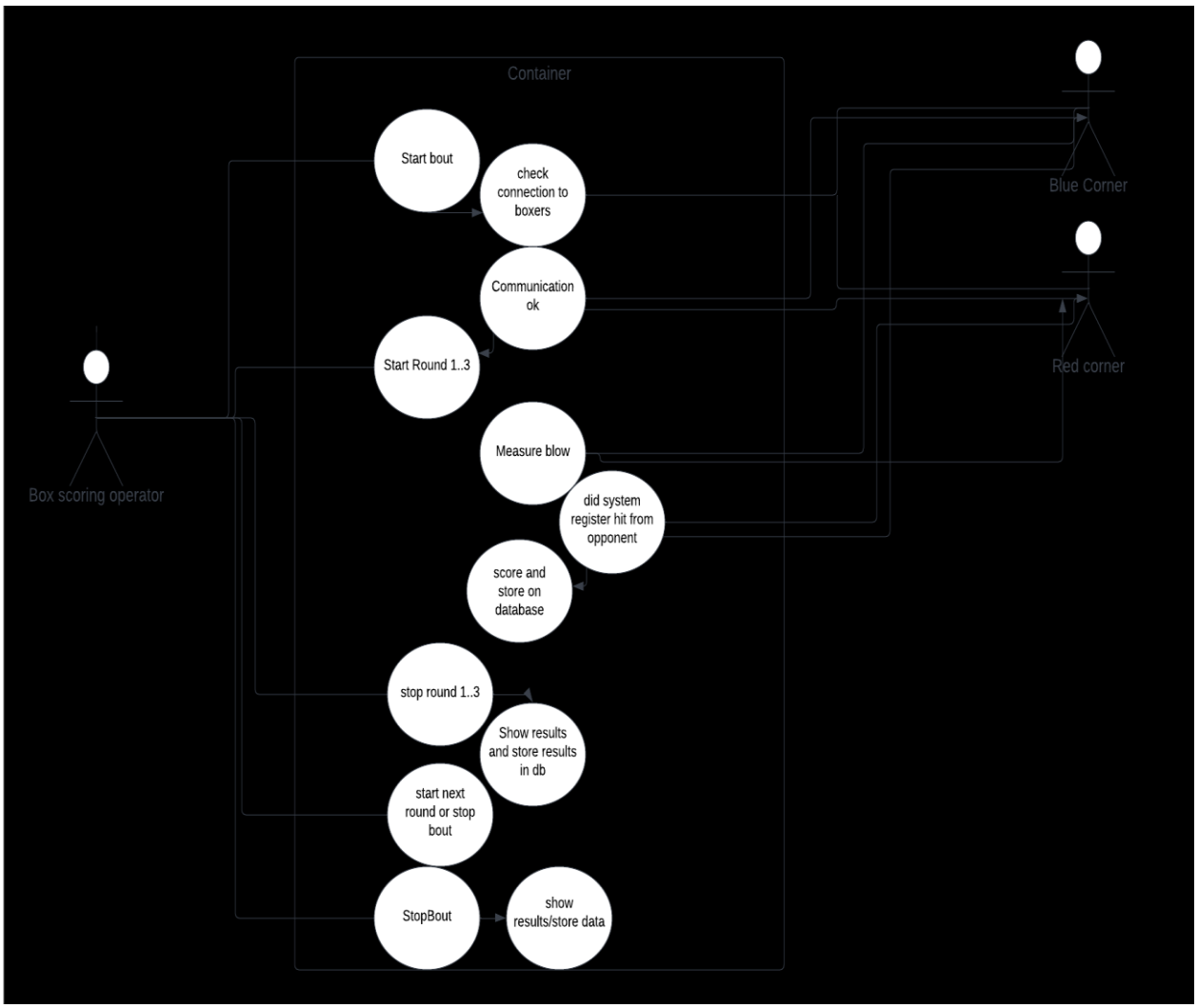


Figure 3. Simplified use case diagram.

Basic functionalities during the bout. The model does not cover interfaces.

5.3 UML sequence diagram of the scoring system

The sequence diagram (Figure 4) should show all the phases of the bout and alternatives used to explain multiple choices like continue/stop and the next round. It also shows sequences of what data is handled. The sequence diagram starts from an end to individual

boxers. Sequence presents one bout consisting of three rounds.

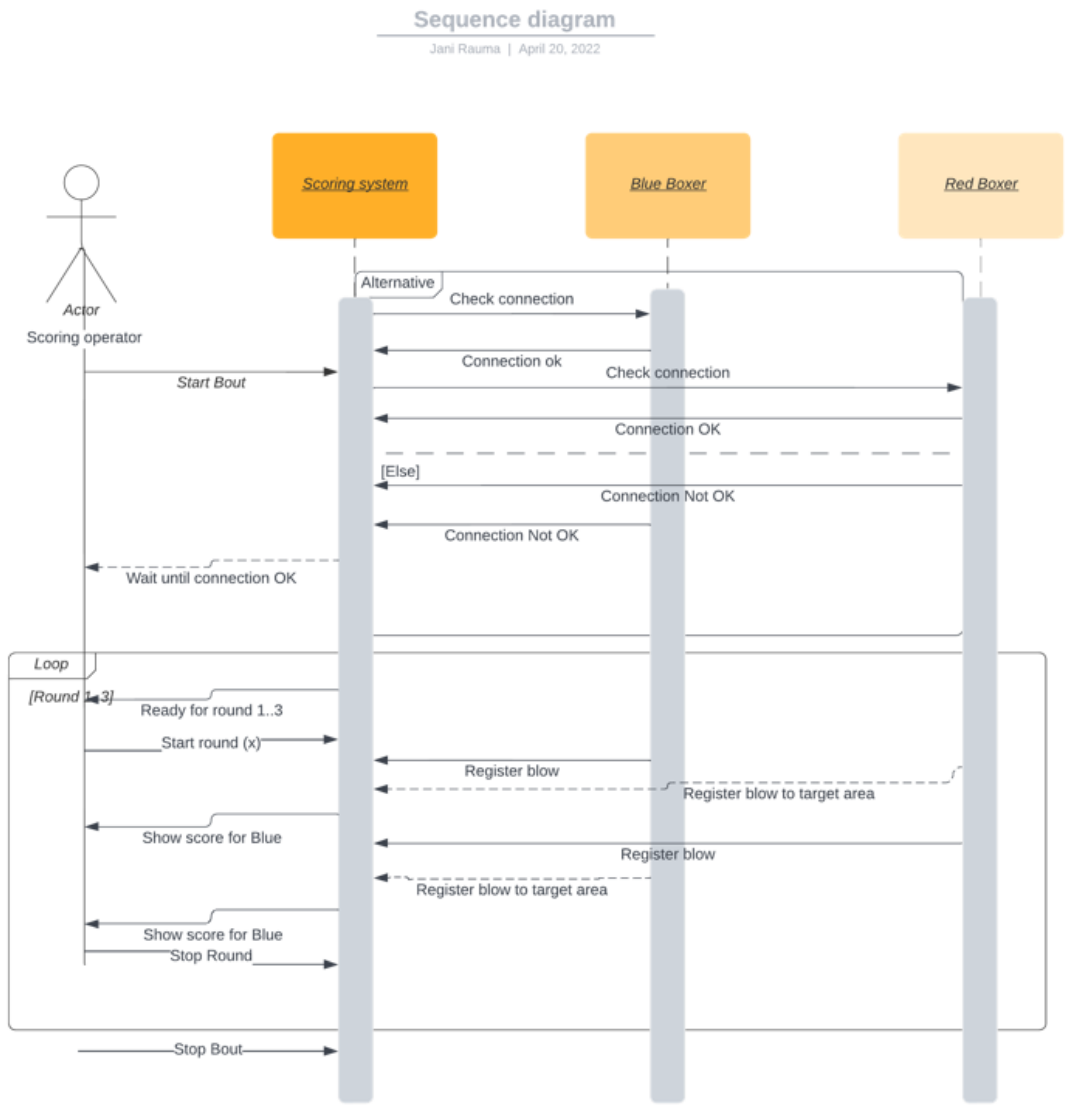


Figure 4 Sequence diagram of a boxing bout.

(Figure 4) explains more detailed information about how the bout consists of three rounds of start and stop phases in the lowest part of the diagram, called the loop.

The actor represents a user who starts and stops bout and each round. Scoring systems are defining a part of the system that has both boxers added. After the start, the system verifies

that both boxers' pieces of equipment are connected online and ready to transmit data. After verifying that boxers are ready, the system starts to read data from equipment and verifies in a LOOP phase that a punch or a blow was verified from the opponent.

If a blow could not be verified, it is marked as a miss. The system stores data from both cases, but only hits are counting scores. The scoring system stores missed blows for later analysis, like the hit/miss ratio. It is similar to counting left and right arm blows, and some other system could analyse types of hit, hit/miss ratio, percentage of power from blows and other interesting statistical data that could be used later on. At the end of the round operator stop ROUND ONE and after a minute, start ROUND TWO. After the third-round system closes the bout automatically, or if the bout ends earlier, STOP BOUT should be done. In general, UML sequence diagrams help represent scenarios and workflows. It represents events in a timeline, but does not tell the state of a component (Rumpe, 2016, p. 193)

5.4 Class diagram of scoring system components

Class diagram should advance the documentation of the scoring system and wearables to be more understandable. Components that produce data could use the UML Class diagram as a base for documenting. The universality of UML modelling should also fit for designing data or interfaces that types of equipment are producing. Working with components of a system that give information about the class that has all documented information (Rumpe, 2016, p. 17). Outside of class as a definition, how classes communicate are associations (Rumpe, 2016, p. 22).The following example in Figure 5. Class diagram example represents a single class.

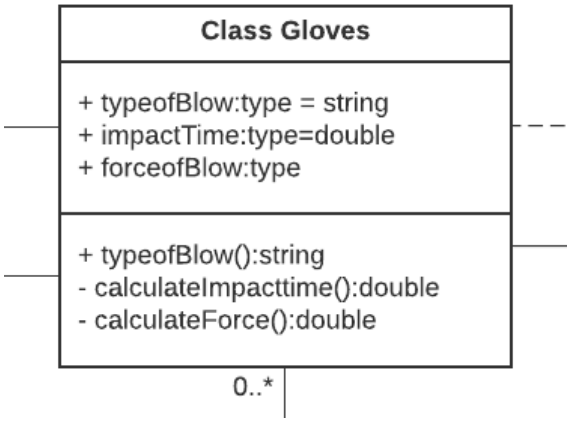


Figure 5. Class diagram example

The class is called gloves, representing boxing gloves and data types it produces. TypeofBlow could be an upper or a lower hook, a jab or punch from the back arm. It also has a parameter, impact time, to tell how long hits are marked. A short impact time could tell about a fast jab, and a longer impact time may present power punches. Long impact time could be marked as a push that is not scored. The lower part tells functions that it uses and their types, public marked as a positive (+) and private marked as a negative (–) symbol.

Next, starting to connect classes, showing how they are represented as a group of glasses—starting from wearables divided by pieces of equipment.

A wearable class represents a superclass or an abstract class, and under it, there are individual classes that represent one type of equipment. A class diagram is a simple way to present the wearables and functions. In addition, the model is easy to expand for future needs.

A Figure 6 below shows the abstract class and its functions to the scoring system through a radio interface. In this model, edge computing is used. Edge computing means that calculations happen on near measurement of data. Each wearable is divided by a class.

Gloves are wearable, as is a vest, a gumshield or a head guard. If further development is needed, new wearables could be added as a new class. A simplified scoring system covers use cases, a sequence diagram of one bout and wearables as types of equipment represented as a class.

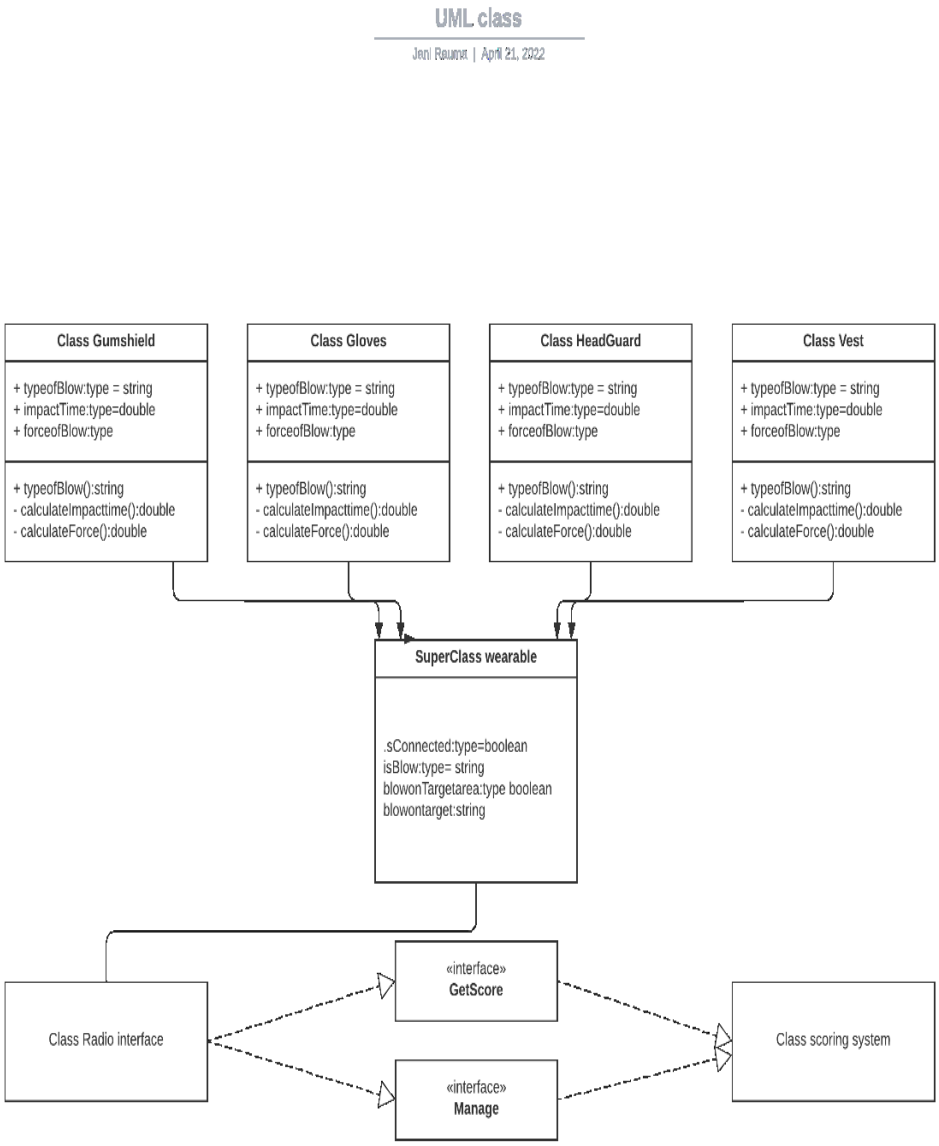


Figure 6 Wearable abstract class with classes.

6 Wearables in boxing

The boxers' wearables and data were produced for the scoring system. Smart clothing makes it possible to recognise a blow on the target area.

From a system point of view, the active equipment contains a sender to send data. The passive equipment is activated activates when the active equipment touches it. For example, gloves touch the knuckle surface (sensors in front of the knuckles) to the opponent's vest and mark a legal blow. The scoring system is shortly defined with interfaces to get data for further analysis, covering what data is stored for a blow and what data a scoring system is used.

The scoring system is developed separately and the licensed vendors produce types of equipment for it. When new types of equipment are presented, they should be added to scoring by accepting and integrating which makes possible the development of equipment. Not licensed vendors can apply the authentication if they are aiming at offering their eligible products. Licensed vendors should produce wearables, or vendors later become licensed. That should provide development for types of equipment.

The usability of wearables and smart textiles includes sustainability, usability and washability. Expensive clothing should be washed without losing features. In competition, textiles are being used and possibly washed. Materials should be tested to ensure that correct results are given. Usability of smart textiles is widely studied and presented elsewhere.

6.1 The Head Guard

The head guard (Figure 7) is one of the possible wearables for measuring the blows aimed on head. The target area of the head is an imaginary line from the ears to the front of the head.

No blows should be targeted behind that line and extra care must be provided that no blows should happen on the backside of the neck.

Figure 7. Competition head guard.(Sting international, n.d.) CC0 1.0.

Possibility to measure a head impact is for example to use a passive textile that is recognized by cloves with a knuckle area sensing. There is no need to have a transmitter on the opponent's head guard when the attacker clove registers a punch aimed at the target area. The only thing that needs to be recognised is the touch of the opponent's wearable with the knuckle area of the gloves. The Head guard should protect the boxer from cuts and the Head guard could have an inertial sensor added to measure the G-forces of blows targeted on the head.

The elite men's boxers do not use a head guard, so a head cap, a net or a thin textile or some other type of wearable should be presented to provide data from the legal blow aimed at the head. The Head guard should be simple but still separate e.g., a situation where blue cloves touch a blue head guard and no point is given. When blue gloves touch a red boxer's, head guard the points are given.

6.2 The vest

One of the most significant target areas is the vest (Figure 8). It is defined as the area from the body's centerline to the front of the body.

Figure 8. Vest and target area (Ahola, 2022) Modified.

The vest covers the upper body and breath well during a competition. The target area should be covered by the passive or the active type of recognizing bouts on the target area. The passive mode does not use an external power supply or send data to the scoring system. Cloves recognise blows on an opponent's surface using the attacker's knuckle area sensors. Identifying a blow should be done by adding a sensor that recognises the opponent's textile

and adds a score if a blow is done legally, and no points are given if it touches any other part of the attacker's glove, like slapping with an inner or an outer side of the glove.

6.3 The trousers or skirt

The trousers (Figure 9) or the skirt has only a narrow area for legal blows, i.e., the beltline. No score is given if the blow goes below the beltline (IBA, 2019). Beltline material should be same as vest material, possibly connected to the vest to analyse legal blows. A blow is detected and scored if the opponent's gloves knuckle area indicates a touch on the beltline.

Figure 9.Trousers and beltline area

6.4 The Gumshield

A gumshield is not only worn to protect the mouth. They could be a good place for inertia sensors detecting G-forces to the head during the bout. There is technology ready to use, but the data it produces is not applied to boxing. Most of the time, a gumshield is used to recognise the hard impact on the head area (Worsey et al., 2019).

It is possible to integrate battery and electronics into the mouthpiece and use Bluetooth for communication. Battery sizes are getting smaller, and those could be inserted inside and side of the gumshield. Charging the battery could be done by inductive charging.

Inertia sensors measure direct hits and will be analysed with data from gloves to ensure that it was a legal blow. Without any other head wearables like a head guard, the first trigger of the blow comes from gloves, which tells that a hit was made by the upper side of the body, meaning that the hit style is an upper hook or a straight. After that, it can be verified by data from a gumshield. Figure 10 presents possible placements for the electronics in the gumshield. When the battery is located at the back of the gumshield, it should be protected by accidentally biting. A sensor located in the mouth should give good information about movements, and it should learn the boxer's normal movement.

Normally, fitting the gumshield for the mouth is done by heating it in hot water, then fitting it in the mouth and biting. However, when sensitive components and batteries are installed, heating and biting are not useful methods for fitting. In this case a better method is to take a cast from a boxer’s mouth and to make a smart gumshield with installed component.

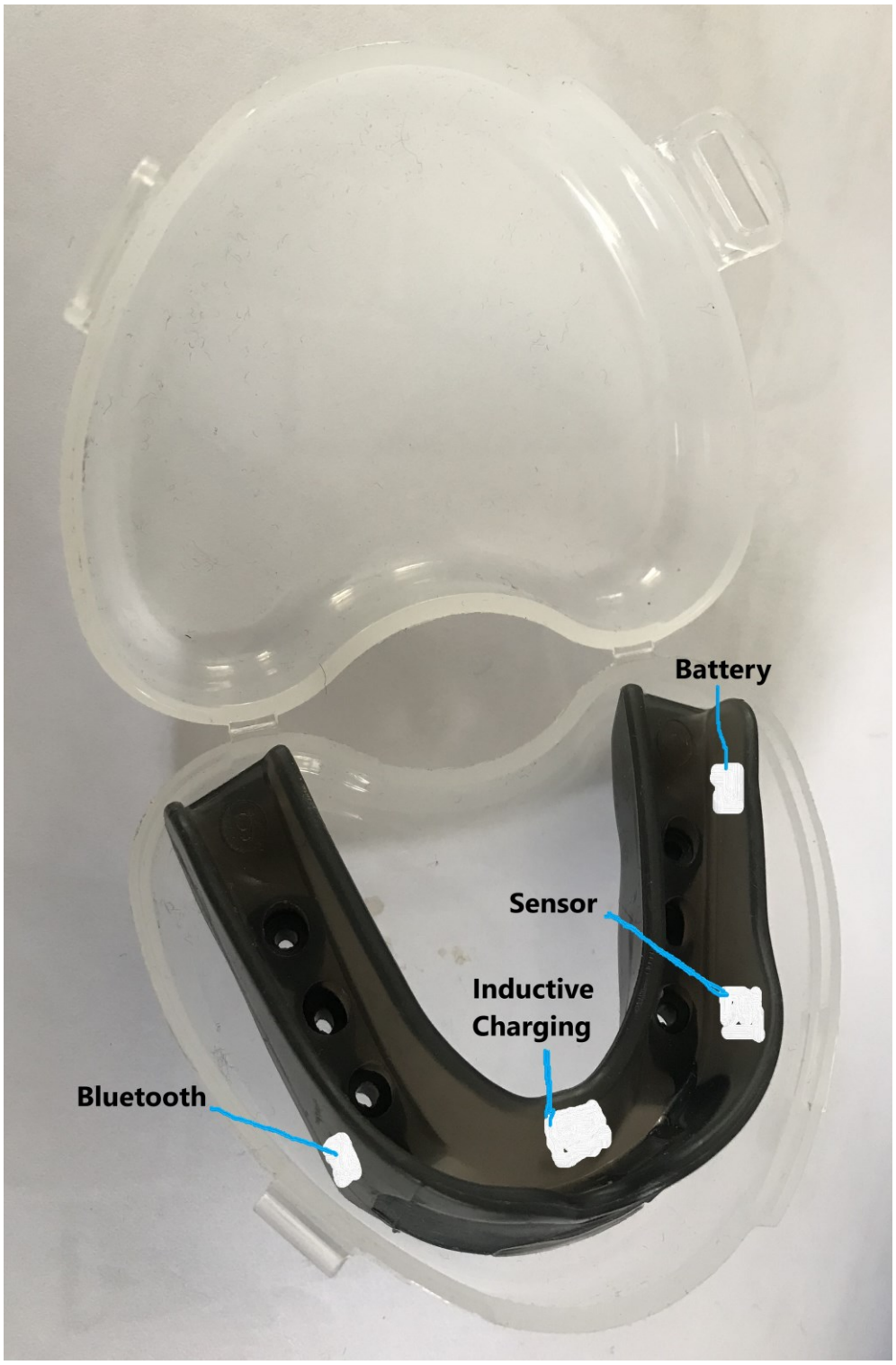


Figure 10. Smart gumshield with possible sensors

Figure 10 shows the gumshield with possible sensor locations. Gumshields need to be fitted on the mouth by a professional to avoid damaging electrical devices. Since it is tightly fitted in mouth it could give realistic data from impacts on head area.

6.5 The Gloves

Figure 11 represent the boxing gloves. Gloves are the essential equipment for producing data for the scoring system, which is done by using inertia sensor technology to analyse any type of blow. Sensors and data give an accurate picture of hand orientation and movement (Rich. et al 2019) The analysis is done by X, Y, Z, and rotation measurements. Using data from inertia produce series of moves which are recognised as types of the blow (Khasanshin, 2021). Support Vector Machines (SVM) could be used as technology (Pernek et al., 2015) ,and data could be analysed near the sensor by using the edge computing. The basic thought is that only recognized blows and data is sent to the scoring system and saved.

Figure 11.Boxing cloves (Sting International, n.d.), CC0 1.0. Modified

Gloves should also identify the touch of the opponent's target area covered by a smart textile vest, a beltline, a head guard or a gumshield and to provide data from an impact. Ensuring that the blow is aimed at the target area with the knuckle area of the gloves can be approached in two ways: 1) first by adding a sensor to a top of the knuckle area of gloves or second 2) installing a small airbag with a pressure sensor inside the gloves. The pressure sensor also measures the impact time, when air is blowing out from a bag.
When the knuckle area touches the opponent's target area covered by an active or a passive piece of textile, a punch type and a registered impact are sent to the scoring system.
Elite series does not use headguards, therefore data from head impacts need to be recognised. In those cases, the gumshields added with inertia sensors should provide reliable data from an impact.

The Artificial Neural Network technology analyses inertia and gyroscope data from gloves and that could be used to teach types of punches and for making algorithms to recognise different blows. Models are then able to test false positive and false negative type of blows (Khasanshin, 2021). To ensure of correct result from sensing area and indicate clear blow, inertia or pressure could be measured to analyse force of a blow. Inertia sensors tell the type of blow, and the touch sensor in the gloves tells that it was marked on the opponent's body or head.

Gloves are one of the most technical parts of wearables in boxing, and they play an essential role in sensing and recognizing the blows. The radio transmitter should send the analysed data to the scoring system. Multiple data senders during a bout should be avoided.
If requested by analytics, it could be possible to send raw data for learning or testing. In a competition, only marked and necessary data should be sent. On target area wearables should activate with a touch of gloves to indicate clear blow. When a red or a blue boxer touches her/his textiles, mark for scoring may not happen e.g., in a case where the

opponent's aim is to blow and it lands on gloves that protect the target area. Another case is when blue gloves touch a blue vest, which shall not be scored.

6.6 Shoes

Data from boxing shoes (Figure 12) are not needed for scoring. It is included for future use and covers what kind of data it could produce.
Shoes have more space for sensors. It might be helpful to measure movement from the feet. Coaches might find it interesting how much a boxer moves when throwing power punches. Measurement of a feet pressure and an angle could be evaluated for telling how they may affect punches and accuracy

Figure 12. Boxing shoes

The boxing shoes differ from the running shoes by better support and a thinner bottom. Boxing shoes do not absorb energy from landing, and therefore sole is thin. Boxers rarely touch the ring apron by the heel so that sensors could be added to the ball of the foot. It is still more straightforward to add battery and sensors on shoes and those could be inserted, for example, on the tongue of the shoe. If sensors are inserted inside the shoes, those should be safe to use.

7 Scoring and smart wearables as a system

Previously were presented the defined components that read data and store it for the scoring as well as the wearables which play a major role in producing data. Wearables should send data within approximately a fifteen-meter range. There should be energy for three times three-minute rounds and one-minute breaks on batteries. Time for entering in the ring and possible injuries during a bout should be considered as well, which means that energy for computing and sending data should last at least twenty minutes.

Bluetooth or some other radio technology can be used for transmitting the data to the scoring system. For Bluetooth, multiple technologies give a good range (Bluetooth.com, 2022a)in the field of play. Bluetooth technology already offers solutions to many-to-many connections (Bluetooth.com, 2022b) That could be the key thing for pairing boxer's pieces of equipment to the scoring system. It allows for adding a secure transport layer to the system, and when paired, it is hard to get in the stream to manipulate the data it sends.

The scoring system collects the data and stores it in the database subsystem for a later use. During and after the bout, the scoring system counts blows on the target area and shows statistics about legal blows at the end of the bout. For the audience, it could be possible to show a histogram of how the forces of the blows have divided, or show the average frequency of the blows.

The scoring system could be used through REST API interface, where statistics could be read during and after the bout. That gives the possibility of reading data online from a system, for example, by publishing a data stream about legal blows to the video recording system. Legal blows could be marked for a red or a blue boxer with some visual highlighting signals for the audience.
Scorecards of the legal blows might be used if a team may protest the results. When blows are marked, it should be easier to find the legal blows from video streams. A typical case for rejecting the blow is that it is not landed on the legal area of the gloves. Using pieces of equipment that produce data and a system stores, it should be possible to extend the

system when new interfaces or types of equipment are being developed. That ensures the development of the boxing as a sport and makes it possible to avoid vendor locks.

The data model or the structure should be extendable for eligible data sources. Data could be served from the scoring system, as a Figure 13 shows through REST API interfaces, and stored in the cloud environment. Thus, collected data could be used in many different applications later on.

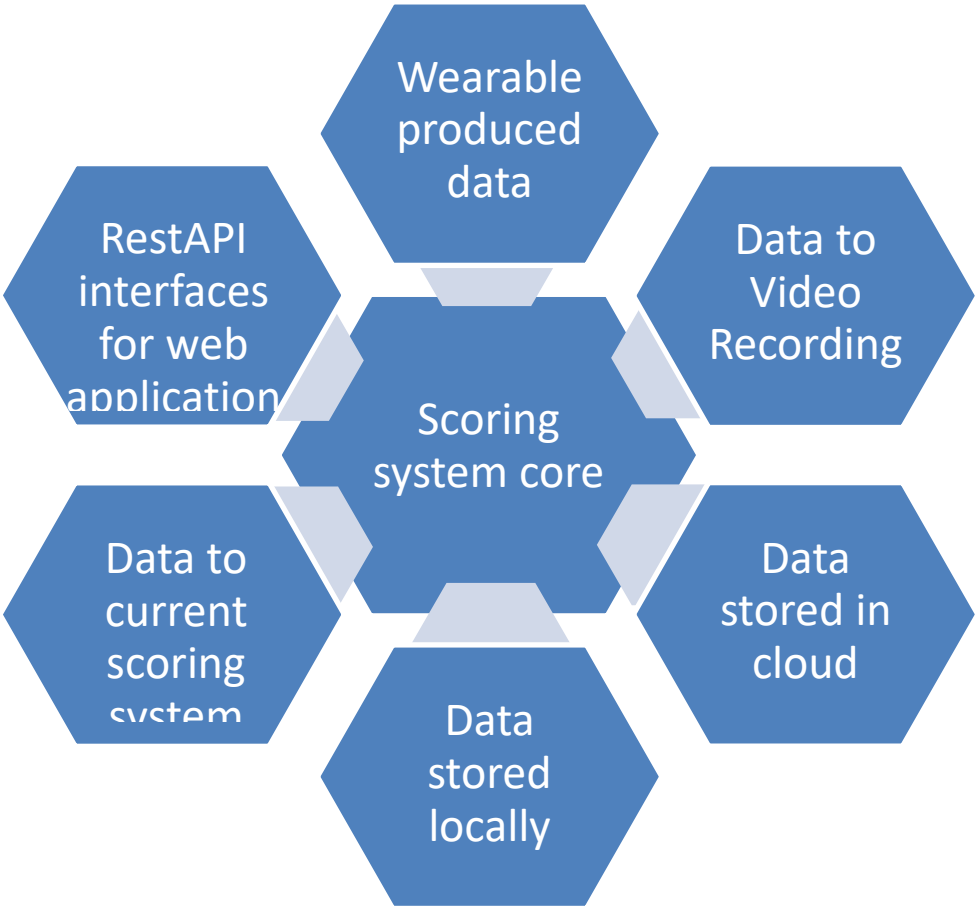


Figure 13. Scoring interfaces.

7.1 REST API

REST API is useful method for sharing information over HTTP (hypertext transfer protocol), and it provides resources that can be used on almost any HTTP client (Surwase, 2016, p. 635).

Data could be divided by the named resources and the methods that operands allow. REST API could act as interface for the scoring system. That allows to use GET to return values similar to database query language. When data from wearables are stored, it is presented out by publishing resources. The Table 2 shows how REST API structure should represent scoring system data. It is possible to query, for example, *<HTTP GET for <http:url/competition?min=2020&max=2022>* and get results of competitions held between 2020-2022. Protecting API is possible to use authentication methods and the API proxy that will hide real endpoints.

Table 2. REST API resources

Service name	information
/competition	information of all bouts
/competition/2022	year 2022
/competition/2022/EUBC_youth	all EUBC youth
/competition/2022/EUBC_youth/bouts/14	2022 EUBC_youth bout 14
/competition/2022/EUBC_youth/bouts/14/statistics	statistics of one bout

REST API method PUT stores data to storage, for example, data from the bout. DELETE method is made for deleting entries. It is possible to choose what methods will be used for interfacing. Wearables use the PUT method for adding data to the scoring system. The Video recording system could read a blow from the interface by using the GET method. The response contains a time of impact in milliseconds and a boxer red or blue.

8 Conclusion

The scoring system extension and components are described theoretically. There are some earlier studies on boxing scoring and wearable textiles, such as a study about the automated scoring system with vests and modified gloves (Hahn et al., 2010).
Also, a study, which have analysed the forces of the blows by measuring acceleration from the wrist have been published by Langholtz (2013). However, Langholtz's (2013) study measured only forces from blows but did not discuss the target area. Performance-based measures for combat sports have presented that inertia sensors are researched (Langholz, 2013), but most studies focus on boxers' safety (Worsey et al., 2019).

The velocity of punches has been measured in research that have explained system definition that has used functional diagrams for visualizing and explaining punches and punch types but did not directly give information for the scoring system (Marković et al., 2021; Urbinati,K. S. et al., 2013).
CompuBox system is briefly explained as a statistical tool for analysing boxing bouts for Television by operators. CompuBox and Punchlab indicated the type of blow or a hit miss by the operator, not by the judge. There are statistics for over 6500 bouts available(CombuBox, n.d.) .

Studies of head impacts support to analyse elite men's bouts where head guards are not used. As a base for this research, forces from head impacts of football and rugby players have been reported(Day, 2020). Many vendors are doing similar studies, which indicates that there is a need for match technology and requirements better together.

Most of the previous systems may fit directly into boxing, but those could not analyse blows aimed directly at the target area. That is one reason for understanding why the available systems have not adopted to boxing. The accuracy of punches analysed is about 92% correct. More accuracy of impacts could be achieved by using multiple techniques. With wearables, the validity of the result should be more than 98% of blows aimed at the target area.

There were the following three research questions presented in this study. First, what are the limitations of the current scoring system; second, what elements and technology are needed for creating the smart system; and finally, which data is needed and how it may flow in the system.

Begin the thesis by researching boxing scoring articles and understanding why articles' solutions are not implemented in current judging. Most studies focused only on one area, vest and gloves, without analysing head area impacts or how data has been used for scoring and interfacing with other systems. The current scoring system uses only a 7-10 scoring (IBA, 2019) and therefore using count of blows does not fit directly on the current system. That could be easier to read through the REST API interface from a separate scoring system. It then read only the data provided.
The greatest challenge was understanding current research and then limiting modelling just for the scoring system and wearable definitions, whereas the easiest issue was finding a way to use the data by different stakeholders.
The used research method was adequate for answering the research questions, but empiric research methods are needed when creating and validating such a scoring system.

8.1 Scoring system thoughts

Swiss Timing has provided boxing scoring systems for years, as explained on its website (Swiss timing, n.d.-a). The system involves of organising weight categories and drawing competitors, judges and referees for the bouts. The theoretical scoring system defined in this study focuses only on a number of clear blows on the target area. How the scoring system will be tested, launched and used is still under investigation.
In theory, the scoring system could be added to the existing system, and then boxing rules need to be modified for considering for choosing the winner.

Another option is to use the scoring system with the Video Recording system for example in a case where a team protests against the decision. In general, technical delegates or jury

look through recordings and analyse the correct winner after a protest. If the scoring system is able to mark clear impacts on a timeline, it would be easier to go through video recordings. The system would be able to tell what are registered as clear impacts.

Using video with the scoring system makes the system more usable, but when thinking about how to add information to the video. Should it be easier, faster, and better to build a platform for boxing scoring data for future use instead of modifying the existing scoring or video systems? New types of smart textiles or wearables could be added to the new system. Data from the new system would be easier to get by publishing a new interface.

8.2 Benefits

Thinking of one bout, we can see either a winner or a loser. If a bout is measured and analysed as a data, it should tell the number of blows per round. It also measures the forces of the blow and how the hard blows are divided from the beginning of the round. It should give some character about the physical condition of the boxer. The system may show statistics of the blows that spread evenly over the round with a sufficient force. It is probably able to show the difference between the winner and a loser in a statistical way. A human is fallible and makes mistakes, and furthermore it is sometimes impossible to see the blows aimed at the target area.

Using innovative equipment should not change boxing itself too much, but it should make it easier to choose the correct winner. When innovative technology is used, the critical point is to eliminate dirty boxing styles, such as slapping on the glove's open side. A winner amount of quality blows means more accuracy and more power on blows aimed. Shot to the body is a technical blow and needs many skills to throw. If it is possible to see a bout as data, it

should be easier to analyse how it went. The benefit for boxers should be a fair judgement. That is the most important thing.

8.3 Coaching with knowledge

Judging a bout is still a personal opinion of the winner. The rulebook introduces criteria to choose a clear winner, but the human eye is watching the round and making decisions. The number of quality blows on the target area is observed by overall criteria. There are no types of equipment from where judges could count impacts. At the same time, they should see that a blow landed with knuckles and had at least reasonable force. Sensors can make that work a bit easier to analyse.

While some judges appreciate the attacking style, some judges see that defending style and counterattacks are still excellent and equal to the attacking style. When the bout is even, secondary criteria should be clear for the judge—getting scorecards to help with hard decisions.

The coaches guide the boxer during the bout and understanding the judging rules brings bits of help. However, due to judges' personal affection about boxing styles, it is still challenging to understand the decision made for the winner.
If the scoring system would be available, the scoring data could help national teams understand the characteristics of being on the top. How many punches were thrown versus accuracy to aim and score?
A Boxer might be an aggressive style fighter who moves spectacularly but focuses on protection and not making clear impacts. Another boxer, a bit passive but sharp, makes impacts only when seeing an open spot in the target area. Therefore, data could show that an aggressive style boxer focusing on protection does not score.

Practical results should be collected from the boxing events to understand the value of scoring data better. Preparing for big tournaments and analysing boxers' data might lead to good results. Data could tell insights into the frequency, the number of blows, and the histogram of forces divided per a round. In addition, statistics collected might be used for coaching.

For everyday training the use of wearable technology or sensors might give good feedback on progress. For example, boxers want to throw 300 blows during a bout with an accuracy of 80% landed on the target.

8.4 Betting

Professional boxing is a sport that one may put a bet. The *Olympic boxing* style is hard to make bets on since there is not enough data on bouts or boxers. By opening the interface and making it possible to see a profile of the boxer, it might be possible to make bets for bouts. That might bring more attention to the Olympic style boxing and it also could be possible to get more audience on the tournaments. That is just an example of use for data provided by the scoring system.

A more extensive events scoring system indicates hard blows, and it is possible to make video screens showing registered hard blows in slow motion. Nowadays, many sports like ice hockey, basketball and football benefit from similar technology.

8.5 Game industry

When developing computer games, data of forces and accelerometers make computer opponents more realistic. At the same time when the player is doing exercise or training techniques, data could correct the style. Creating games is not only by just boxing with a virtual opponent but playing a game can happen with a group of people which is working out with shadow boxing by following the instructions provided by a computer.

Raw data used in the game industry could assist making incredibly realistic games, where actual bouts have provided data.

8.6 Fitness

Training in fitness boxing without hard contacts could have many benefits for scoring system data and the use of wearables. Measured data may motivate individuals to reach some targets on personal training. The target could be the amount of thrown punches per minute or corresponding. The trainer starts the season by doing exercise when the system gives an insight into the physical condition. That should be the positive feedback to see how much faster, more blows or better accuracy is gained during the training season.

Using smart wearables in a gym might lead to different games. Who is the fastest, doing more blows than others without the risk of injuries from physical contact. That should motivate fitness boxers to continue the hobby and might give some new targets.

A Boxing gym is typically maintained by a group of individuals with an enthusiastic approach to boxing. Funding sports might be related directly to fitness boxers. Fitness boxers might find it interesting to analyse their level of physical condition compared to some real team boxers.

8.7 The following steps

Currently, there is no ready system for users. That was a trigger to this study, and the next step is trying to explain the scoring system by using understandable notation that explains the system. Wearables are defined by abstract functions they fill and the data they provide. Conclusion explained interfacing the scoring system and continuing use of data. Work should continue and to be more detailed for the equipment development or scoring development. Usage of data in the conclusion part is for applied applications, fitness, game industry and

coaching boxers. Considering that there is currently no data available that may be used for those applications, it might be motivating to develop such a system for sports.

References

Alam, F., RoyChoudhury, S., Jalal, A. H., Umasankar, Y., Forouzanfar, S., Akter, N., Bhansali, S., & Pala, N. (2018). Lactate biosensing: The emerging point-of-care and personal health monitoring. *Biosensors and Bioelectronics*, *117*, 818–829. https://doi.org/10.1016/j.bios.2018.06.054

Blazquez, M., Alexander, B., & Fung, K. (2020). Exploring Millennial's perceptions towards luxury fashion wearable technology. *Journal of Fashion Marketing and Management: An International Journal*, *24*(3), 343–359. https://doi.org/10.1108/JFMM-09-2019-0200

Bluetooth.com. (2022b). *Device Networks*. Bluetooth® Technology Website. https://www.bluetooth.com/learn-about-bluetooth/solutions/device-networks/

Bluetooth.com. (2022a). *Understanding Bluetooth Range*. Bluetooth® Technology Website. https://www.bluetooth.com/learn-about-bluetooth/key-attributes/range/

Chong, T. (2014). Firefighters get life-saving wearables [News]. *IEEE Spectrum*, *51*(10), 22–22. https://doi.org/10.1109/MSPEC.2014.6905476

CombuBox. (n.d.). *Compubox*. Retrieved May 27, 2022, from http://beta.compuboxdata.com/categorical-leaders

Day, L. (2020, February 10). Rugby concussion: Swansea University study into protecting women. *BBC News*. https://www.bbc.com/news/uk-wales-51434749

Edward, T. (2006, March 1). *Amateur boxing explained*. http://news.bbc.co.uk/sport2/hi/boxing/4733928.stm

FIE. (2021). *Fencing technical rules eng.* Federation International D'escrime. https://static.fie.org/uploads/26/131735-technical%20rules%20ang.pdf

Hahn, A. G., Helmer, R. J. N., Kelly, T., Partridge, K., Krajewski, A., Blanchonette, I., Barker, J., Bruch, H., Brydon, M., Hooke, N., & Andreass, B. (2010). Development of an automated scoring system for amateur boxing. *The Engineering of Sport 8 - Engineering Emotion*, *2*(2), 3095–3101. https://doi.org/10.1016/j.proeng.2010.04.117

Hauser,T., Olver, R., Krystal, A., Nigel, C., Sammons, J.T., Wallenfield, E.C., & Poliakoff, M. (2021, December 16). *Boxing | History, Rules, Weight Divisions, Notable Fighters, & Facts | Britannica*. https://www.britannica.com/sports/boxing

Herbert, R. (2012). *Legal Blow?* https://www.flickr.com/photos/turbozmr2/7991339661/sizes/l/

IBA. (2019). *RJ_Manual_Document_2019__01.pdf*. https://www.iba.sport/wp-content/uploads/2019/01/RJ_Manual_Document_2019__01.pdf

IBA. (2021). *AIBA-Technical-and-Competition-Rules_20.09.21.pdf*. International Boxing Association. https://www.iba.sport/wp-content/uploads/2021/09/AIBA-Technical-and-Competition-Rules_20.09.21.pdf

Khasanshin, I. (2021). Application of an Artificial Neural Network to Automate the Measurement of Kinematic Characteristics of Punches in Boxing. *Applied Sciences*, *11*(3). https://doi.org/10.3390/app11031223

Langholz, N. (2013). *Pulling Punches: A Non-parameteric Approach to Punch Force Estimation and the Development of Novel Boxing Metrics*. https://escholarship.org/uc/item/19s6p5ct

Marković, S., Kos, A., Vuković, V., Dopsaj, M., Koropanovski, N., & Umek, A. (2021). Use of IMU in Differential Analysis of the Reverse Punch Temporal Structure in Relation to the Achieved Maximal Hand Velocity. *Sensors*, *21*(12). https://doi.org/10.3390/s21124148

Naruo, T., Kawashima, K., Kimura, T., Oota, Y., & Kanayama, T. (2013). Golf swing analysis by an inertia sensor and selecting optimum golf club. *ISBS - Conference Proceedings Archive*. https://ojs.ub.uni-konstanz.de/cpa/article/view/5586

Pernek, I., Kurillo, G., Stiglic, G., & Bajcsy, R. (2015). Recognizing the intensity of strength training exercises with wearable sensors. *Journal of Biomedical Informatics*, *58*, 145–155. https://doi.org/10.1016/j.jbi.2015.09.020

Rahaman, M. M., Fang, W., Fawzi, A. L., Wan, Y., & Kesari, H. (2020). An accelerometer-only algorithm for determining the acceleration field of a rigid body, with application in studying the mechanics of mild traumatic brain injury. *Journal of the Mechanics and Physics of Solids*, *143*, 104014. https://doi.org/10.1016/j.jmps.2020.104014

Rodin, D., Kirby, M., Sedogin, N., Shapiro, Y., Pinhasov, A., & Kreinin, A. (2019). Comparative accuracy of optical sensor-based wearable system for non-invasive measurement of blood glucose concentration. *Clinical Biochemistry*, *65*, 15–20. https://doi.org/10.1016/j.clinbiochem.2018.12.014

Rumpe, Bernhard. author. (role)aut (role)http://id. loc. gov/vocabulary/relators/aut. (2016). *Modeling with UML Language, Concepts, Methods* (1st ed. 2016.). http://lib.ugent.be/catalog/ebk01:3710000000873013

Sting International. (n.d.). *Gloves,Modified*. Retrieved May 27, 2022, from https://www.flickr.com/photos/135349301@N06/46895884204/sizes/o/

Surwase, V. (2016). *REST API Modeling Languages—A Developer's Perspective*. *2*(10), 4.

Swain, A. (2020, July 16). What is UML Diagram…. *Coffee with The UI Girl*. https://medium.com/the-ui-girl/what-is-uml-diagram-bf9bf8f4a573

Swan, M. (2012). Sensor Mania! The Internet of Things, Wearable Computing, Objective Metrics, and the Quantified Self 2.0. *Journal of Sensor and Actuator Networks*, *1*(3). https://doi.org/10.3390/jsan1030217

Swiss timing. (n.d.-a). *Boxing Scoring System*. https://www.swisstiming.com/fileadmin/Resources/Data/Datasheets/DOCM_BX_ScoringSystem_1215_EN.pdf

Swiss timing. (n.d.-b). *Fencing—Swiss Timing*. Retrieved May 27, 2022, from https://www.swisstiming.com/sports/fencing/

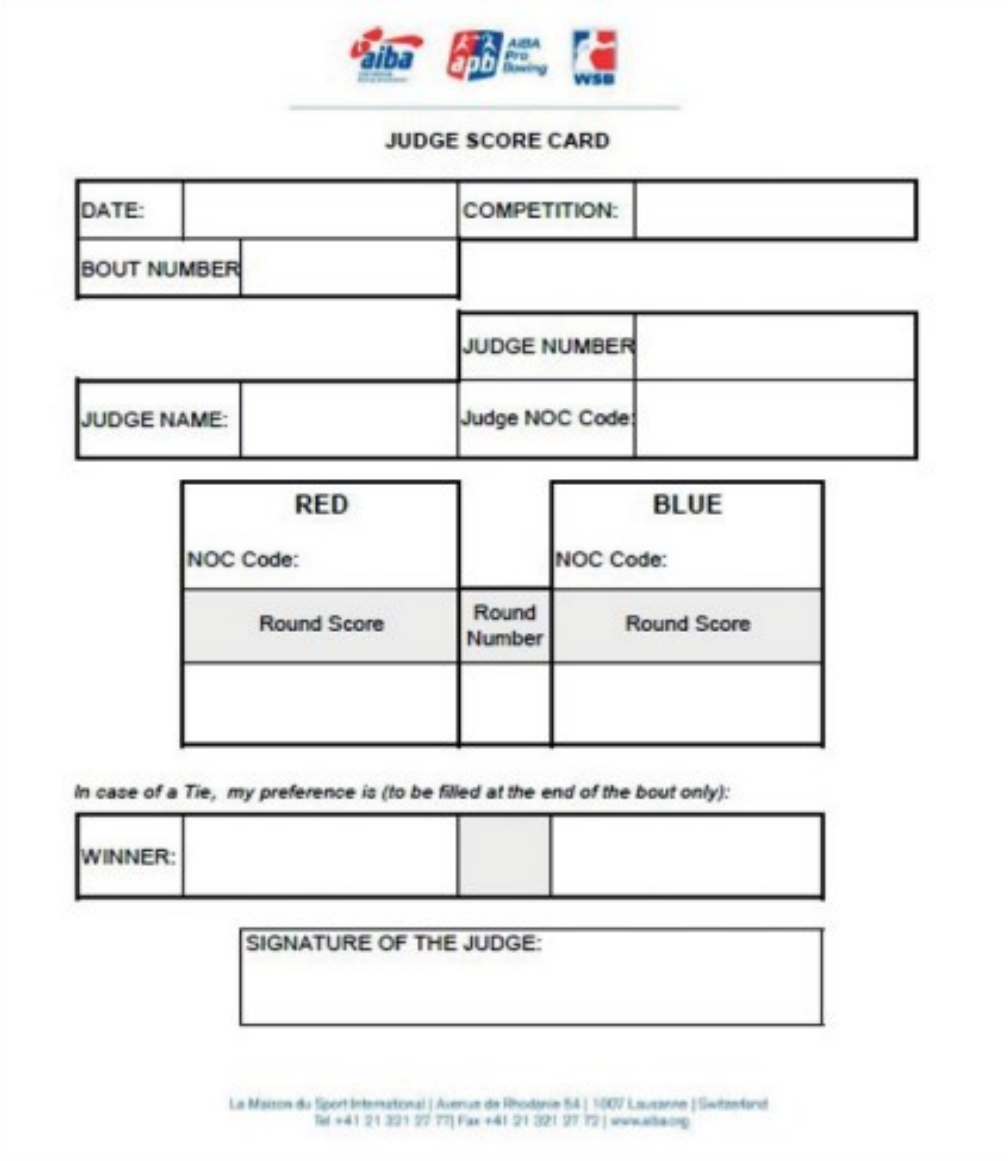
Urbinati,K. S., Scheeren,E., & Nohama,P. (2013). A new virtual instrument for estimating punch velocity in combat sports. *2013 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 571–574. https://doi.org/10.1109/EMBC.2013.6609564

World of Taekwondo. (n.d.). *WT Competition Rules Interpretation (June 1, 2022)_final.pdf*. Retrieved May 27, 2022, from http://www.worldtaekwondo.org/viewer_pdf/external/pdfjs-2.1.266-dist/web/viewer.html?file=http://www.worldtaekwondo.org/att_file/documents/WT%20Competition%20Rules%20%20Interpretation%20(June%201,%202022)_final.pdf

Worsey, M. T., Espinosa, H. G., Shepherd, J. B., & Thiel, D. V. (2019). Inertial Sensors for Performance Analysis in Combat Sports: A Systematic Review. *Sports*, *7*(1). https://doi.org/10.3390/sports7010028

Wu, L. C., Laksari, K., Kuo, C., Luck, J. F., Kleiven, S., 'Dale' Bass, C. R., & Camarillo, D. B. (2016). Bandwidth and sample rate requirements for wearable head impact sensors. *Journal of Biomechanics*, *49*(13), 2918–2924. https://doi.org/10.1016/j.jbiomech.2016.07.004

Attachment 1: Judge score Card (International Boxing Association, 2018)



JUDGE SCORE CARD

DATE:		COMPETITION:	
BOUT NUMBER			
		JUDGE NUMBER	
JUDGE NAME:		Judge NOC Code:	

RED NOC Code:		BLUE NOC Code:
Round Score	Round Number	Round Score

In case of a Tie, my preference is (to be filled at the end of the bout only):

WINNER:			

SIGNATURE OF THE JUDGE:

La Maison du Sport International | Avenue de Rhodanie 54 | 1007 Lausanne | Switzerland
Tel +41 21 321 27 77| Fax +41 21 321 27 72 | www.aiba.org