Automatic Race Start System for Hearing Impaired Athletes

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ABSTRACT

There is an increasing desire of deaf and hearing-impaired athletes to test their abilities by taking part in open events against all competitors. However, few athletes with such sensory disabilities are able to compete on equal terms in short-distance races (60m, 100m, 100/110m hurdles, etc.) where rapid reaction to the audial start signal is vital to competitive success and top performances. The normal ways for these athletes to realise the starter's gun has fired involve a disadvantageous change in starting position and or a time delay of up to several tenths of a second. This report describes a project to create a system that detects the sound of the starter's gun and automatically communicates it to the athlete through a portable light unit. It covers the development, testing and commercial roll out of the Olimpo Device, which the authors suggest can also be used in training and in other sports. The project was named the winner of the Technology Category in the 2012 European Athletics Innovation Awards and the commercial product has been used at a number of national and international competitions.

AUTHORS

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Introduction

The International Committee of Sport for the Deaf or ***Comité International des Sports des Sourds*** (ICSD) was founded in 1924 to promote equality through sport and the interests of deaf athletes by, among other means, staging the International Silent Games, now known as the Deaflympics. The recognition of the ICSD by the International Olympic Committee in 1955 coincided with increasing recognition of the importance of sport as a tool for rehabilitation, integration and adding value to the lives of people with disabilities. Following the staging of the first Paralympic Games in 1960, adapted sports for those with disabilities have grown in popularity and become more established in the mainstream to the point where the staging of the Paralympics is now integrally linked to that of the Olympic Games themselves.

This trend has led to adapted sports embracing a wide variety of disciplines that are now practiced at both the recreational and competitive levels. These include athletics, biking, swimming, wheelchair tennis, table tennis, football, archery, basketball, volleyball, sailing, skiing, weightlifting, boccia, goal ball and others. The development of assistive technologies has increased the interest of sportsmen and sportswomen with disabilities in competing against other competitors with and without disabilities. However, despite these advances, it is still difficult to say that there is equality of opportunity between competitors.

For example, few athletes who are deaf or hearing-impaired are able to compete on equal terms in short-distance races (60m, 100m, 100/110m hurdles, etc.) where rapid reaction to the audial start signal is vital to competitive success and top performances. This is because the normal ways a deaf athlete realises the starter's gun has fired is by perception of the vibratory motion of the ground produced by the sound of the shot, by visual observation of the flash or the smoke of the shot, or with the help of an assistant, who after hearing the shot waves a flag or touches the back of the athlete informing that he/she must start. All of these involve a disadvantageous change in starting position and or a time delay of up to several tenths of a second. Only in international championships for deaf athletes is there a light-based system for starting.

The aim of the project described here was to create a means that could be used in any athletics meeting to put deaf and hearing-impaired runners on an equal footing with the others. It arose from the desire of athletes with sensory disabilities to test their abilities by taking part in open events. A second and equally important aim was to contribute to the mission of the ICSD and others in the field of disability sport by helping to motivate and support people with sensory limitations to take part in athletics at both the professional and amateur levels and thereby foster the use of the sport and physical activity in general as therapeutic and socialising tools for this group.

Our main objective was to develop a system to detect the sound of the starter's gun and automatically communicate it to the athlete through an accessible interface in way that minimises any delay or disadvantage. The electronic and software system we have developed does this and includes other features such a light signal informing the athlete of the starter's "set" command and a vibrating wristband that is activated in the case of a false start.

In this report we describe the development, testing and final commercial product that resulted from our project.

Development Process

The project started in 2010 as a collaboration between the Department of Physical Education and Sports, at the University of the Basque Country in Spain and the Spanish electronic engineering company ENKOA SYSTEM S.L, Mendaro, Spain. The participation of ENKOA was a reflection of the company's philosophy of social responsibility and willingness to help by sharing its know-how in technology. We also had invaluable assistance from the Adapted Sports Federation of the Gipuzkoa province in Spain.

The work included research on available technologies for sound capture and wireless networking, assessment of the market and the various risks involved; design and testing of a prototype system; and the development of the prototype into the currently available commercial product called Olimpo Device.

Demands

From the outset we identified the following set of challenges to be addressed in the project and achieved in the final product:

Speed: Once the starting gun is fired, the light indicating the start should be seen by the athlete as simultaneously as possible. For this, the system requires reliable and efficient communication between the gun or other mechanism that gives the starting signal and the indicator lights.

Synchronisation: In the case of centralised architecture, the starting lights for all athletes using the system should turn on at the same time in order to avoid advantages.

Autonomy and Independence: The system should work at any competition at which the start of the race is by a starting gun as well as in training sessions. It should be battery operated and not reliant on the availability of a power source at the stadium or training area. It should not affect any currently existing system.

Size and Portability: The size of the receptor unit should allow for placing it next to the athlete at the start without violating regulations or disturbing other participants. The whole system should be of a size that allows the user to carry it in the same kit bag used for competition equipment and clothing.

Sealing: The system should be able to withstand all inclement weather conditions.

Aesthetics: The system should be provided according to the aesthetics defined for this type of sports equipment.

Design concept

The basic concept we used in creating the prototype system comprised the necessary means for the sound of the starting signal (the starter's gun) to be picked up by an instrument, such as a mobile telephone or wireless microphone, and transferred to a signal processing unit where it would be converted to the signal that could activate a light or vibration that would inform the athlete to start (see Figure 1).

To this we added a second mobile signal source that would be operated by the athlete's coach or assistant and would feed into the signal processing unit. This would allow the coach or assistant to activate a light that informs the athlete that the starter has instructed the athletes to assume the "set" position.

Process priorities

The focus of our work in the development phase was on the following points:

Reaction: The time of receipt of the sound wave by the signal processing unit and the communication to the interfaces is a critical aspect of this project. The overall system reaction time had to be of the order of milliseconds. We carried out time tests and analysed the behaviour of all components, minimised the number of electronic components and optimised the embedded code. In the final product, the reaction to the shot is less than one millisecond.

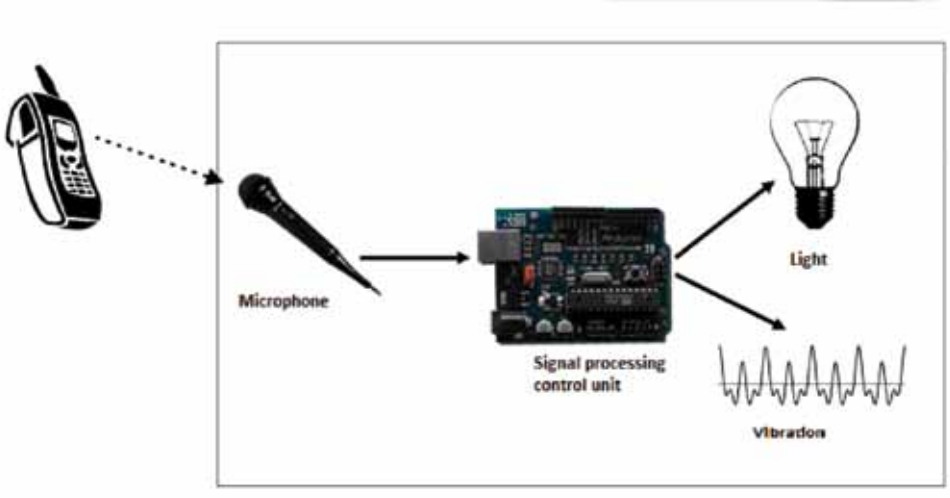

Figure 1: Prototype schematic

Wireless Technology: To maximise the performance of the wireless technology, several sensor networks and receivers located at different distances were analysed in order to determine the best structure. Connectivity was tested with different protocols measuring the influence of the separation and delimiting the range.

Battery Performance: There was a comprehensive analysis of energy consumption of system components to increase the life of the battery / batteries for the product. It was developed in way that the device is on standby until the actual time of use in the race. In the final product the nine-volt battery duration is 40 hours when switched on and up to two years when switched off.

Prototype Testing

For our initial system tests the calibration and test shots were performed with the device placed at various distances up to eight lanes away from the starter's shooting position. In all cases the device reacted perfectly to the shots fired and the system response was correct.

After that our main testing objectives were 1) to see if hearing-impaired athletes could adapt to and benefit from the system and 2) to check certain variables to understand the interface that would give the best results from the athlete's point of view. For this we worked with a hearing impaired athlete under the supervision of his coach and officials from Adapted Sports Federation of Gipuzkoa. In fact, the test conditions were not ideal as the athlete did not have his competition shoes and had to make do with normal training shoes. We tested a version of the prototype that consisted of a remote control for the coach and a light indicator device that by different colours could signal both SET and GO (Figure 2 and Figure 3). For some of the test starts we used a red LED light to signal the start and for others we used a green LED light. To assess the quality of the test starts we used starting blocks with the ReacTime System (Lynx System Developers, Haverhill, Massachusetts, USA), which included accelerometers for determining exactly when the athlete reacts to the start signal (Figure 4).

According to the IAAF Rules, a reaction time measured by an approved false start detection system of less than 100 milliseconds is considered a false start. Reaction times between 130 and 170 ms can be considered very good for elite athletes with normal hearing ability. For example, in his 2009 world record races Usain Bolt (JAM) had reaction times of 146 ms (100m – 9.58) and 133 ms (200m – 19.19). The initial data provided about our test athlete indicated that in previous competitions his average reaction time was approximately 500 ms, which is good for a hearing-impaired

Figure 2: Prototype coach's control unit

Figure 3: Prototype athlete receptor

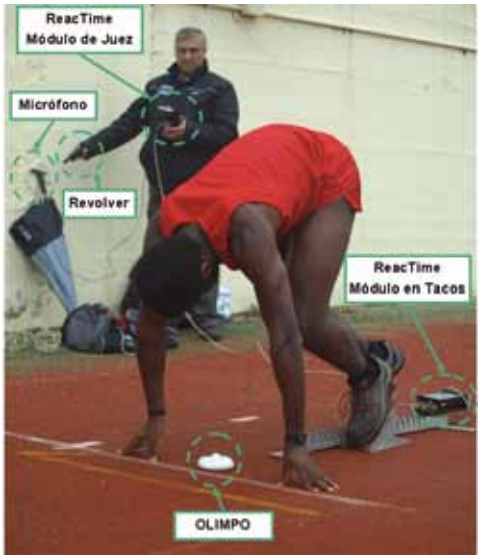

Figure 4: Product testing with an athlete in coaching session.

athlete but far below the standard required to compete successfully against athletes without a hearing impairment.

Fifty starts were conducted and analysed. Again, the device itself worked perfectly. Even though it was his first contact with this version of the prototype, the athlete, his coach and the federation staff were all amazed at the athlete's swift response to the starting gun using the device. His best reaction to the green light signal was 217 ms and to the red light signal was 193 ms.

Although the number of test starts could be considered limited, we could see that the improvement on our test athlete's initial data of 500 milliseconds was considerable. We believed that after a process of familiarisation with the device it would be possible for him and other hearing-impaired athletes to reach values of 180 ms or less. Moreover, we had an indication that different coloured LED lights as well as the contrast against white or black background could make a difference. For this reason, the final product now features individually configurable colours.

Following the initial try-outs, our test athlete successfully used the prototype in competition at the 2011 Casimiro Ondo Championship of Adapted Sports in Basauri, Spain.

Commercial Product Description

The prototype has since been developed into a commercial product called the Olimpo Device. The device is standalone, portable and battery operated. The main features are:

High-Sensitivity Microphone and High-Speed Processing Electronics: Detects the sound of the starting gun through a microphone integrated in the sensor and immediately turns on the LED in the Athlete Receptor to indicate the start of the race. The threshold for shot intensity is configurable.

Athlete Receptor: A small (110mmx 40mm, 120 grs) wireless unit that displays a high visibility configurable LED lights against a black background (Figure 5).

Figure 5: Olimpo Device Athlete Receptor with configurable colours

Coach's Remote Control Unit: Signal device that communicates wirelessly to the Athlete Receptor to indicate the Starter has called for the athletes to be set (Figure 6).

Figure 6: Olimpo Device Coach's Remote Control Unit

Detailed product specifications and prices are available from ENKOA SYSTEMS, S.L. (www.enkoa.com).

Roll Out Chronology

In 2012 the project was named the winner of the Technology category of European Athletics Innovation Awards. The judges remarked that by helping to put hearing-impaired athletes on an equal footing with other competitors such a system was extending the benefits of the sport of athletics. That summer the Olimpo Device officially debuted in competition at the Spanish Sports for the Deaf Championships.Several athletes used the device at the 1st European Junior Denf Athletics Championships in Poland.

In 2013 the device was used at the Spanish Athletics Championships and the Spanish Adapted Athletics Championships. In 2014 the Spanish Federation of Adapted Sports and the Association of Adapted Sports in Essen, Germany, purchased Olimpo devices.

Conclusion

From our experience with this project we can conclude that with the use of enabling technology it is feasible for hearing-impaired athletes to compete in sprint events on an equal footing with athletes who do not have such disabilities.

This report has shown how the automatic start signal detection system was developed and that it can improve sensorial impaired athlete performance in terms of reaction time. It also documents the commercial product that was developed and its initial roll-out. As well a athletics competitions, the product has applications in training and in other sports such as skiing and rowing.

We hope that our project and the information provided here will inspire and motivate more deaf and hearing-impaired individuals to participate in athletics and sport in general.

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