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<td><strong>Closing Remarks and Poster Awards.</strong> Dr Geoff Garrett, Professor Joe Baker</td>
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Preface

The development of the Australian Sports Technologies Network (ASTN) comes at a pivotal time in the evolution of sport technology in Australia with the industry rapidly growing world-wide.

The State of Queensland has a strong international reputation for sport technology innovation through the success of its elite athletes and activities of Queensland research institutions and small and medium enterprises.

The inaugural ASTN Queensland Node Seminar presents an opportunity to enhance collaboration and networking in Queensland between sport technology stakeholders and provide a collection of short papers that represent some of the sport technology initiatives being conducted in Queensland.

With the support of its hosts (the Queensland Sports Technology Cluster; Queensland Academy of Sport Centre of Excellence for Applied Sport Science Research; and Griffith University), ASTN (QLD) hopes you enjoy today’s activities and looks forward to your continued support in enhancing sport technology strength in Queensland.

Dr Daniel A. James
ASTN QLD Node
Relationship Between Wrist and Bat Acceleration in Cricket Batting

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ABSTRACT

In cricket, bat and limb mounted miniature movement sensors could be useful for the assessment and understanding of effective batting. Literature shows that the interaction between the batter’s limbs and the bat is an important issue for batter performance in cricket [1-3]. The correct grip and coupling between the hand and bat play a vital role in ball control. An understanding of hand-bat coupling before, at and after contact enables a coach to prepare the batters for improved stroke play. This work examined the use of small, low-cost, three dimensional motion sensors to assess the coupling of the top and bottom hand with the bat in a defensive stroke.

Triaxial inertial sensors can be used for cricket bat swing interpretation [4]. Using sensors on the bat, the left and the right wrists of five novices, the ball-contacts in defensive strokes were recorded. The players were asked to hit the incoming ball along the ground. The ball was delivered using an underarm throw at slow speed and without swing. The bat swing was in the x-z plane of the sensor placed on the reverse face of the bat (the bat face was in the z direction). The velocity of the wrists and bat was derived by integrating the acceleration data.

The total acceleration was calculated one second before and after of ball-contact. Large spikes in the total acceleration indicated the ball-contact. Three novice data sets revealed that the top hand (left hand for a right handed batter) was more strongly coupled with the bat before and after contact having a smaller acceleration difference with bat than the bottom hand. The other batters showed neither hand was coupled properly with the bat. A second deflection showed inferior quality of ball-contact caused by the jarring.

The velocities were calculated from the acceleration data using the method described in [5]. The wrist velocities were plotted against bat velocity for each novice. A linear relationship (slope > 0.64) was found for
the left wrist and slope > 0.44 for right wrists (r > 0.7). This shows that the left hand was dominant (consistent with the literature [1]) except for two novices whose drives showed the bottom hand consistently dominated the action. Accelerometer sensors can provide useful information about the grip on the bat during ball contact.

REFERENCES


Horizontal Radiation Pattern from a 2.4GHz Waist Mounted Beacon for Indoor Basketball Player Positioning

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ABSTRACT

The game of indoor basketball is played at the professional level in many countries around the world where state of the art facilities and technologies assist basketball players and coaches improve their team’s performance [1, 2, 3]. Technologies for detecting, tracking and positioning of players within indoor team sports have attracted a growing interest in recent years [4,5]. The ability to provide real and recorded movement of players provides valuable information for coaches to analyse and improve the performance of their offensive and defensive plays.

Within these locating systems there are a number of key components that engineers need to consider during the design, such as the communications methodology, the positioning technique, the placement of the wearable beacon and the receiver locations. For radio signal positioning systems in indoor sports, a small transmitting beacon is worn by the player. The location of this beacon on the player will contribute to the overall horizontal radiation pattern produced and the resulting lobes and nulls will affect the position determination of transmitted location. The knowledge of these lobes and nulls in the radiation pattern is important in the positioning system design.

Triangulation or trilateration is a common mathematical technique used in these locating systems to approximate the player’s position and is based on the calculated or known distances from the player towards two or more known locations (receivers). Approximate distances to each receiver can be determined mathematically from the steady signal strength or time delay recorded at each of the receivers. By measuring and considering the transmitting radiation pattern in the design we can attempt to minimise signal strength variations in the signal path due to lobes and nulls in the pattern. This will improve the estimated distance accuracy.

In the sport of basketball during offensive play, the players will mostly be facing towards their basketball ring (i.e. towards one end), while during defensive play the players will be facing the opposite direction or in the same
direction when a defensive rebound is required. The players undertake a wide range of movements which influence the positional accuracy (eg bending during dribbling). These are some of the factors considered along with the radiation pattern in the design of the location system and the preferred placement on the body of the transmitting beacon.

This paper reports the horizontal radiation pattern of a waist mounted vertically polarised beacon transmitting at 2.4GHz, the influence of the body on the radiation pattern and discusses the radiation pattern for employment in a wireless indoor basketball positioning system. The technique appears viable if four receiving sites are deployed around the court.

REFERENCES


Contention in team sports: Can we measure it?

William Gageler\textsuperscript{1}, Jonathon Neville\textsuperscript{1}, Daniel A. James\textsuperscript{1,2,3}, David Thiel\textsuperscript{1}

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ABSTRACT

In team sports contention or player to player impacts are a common occurrence and a leading cause of sports related injury. In addition, contention is a high intensity event which can occur multiple times and take a significant toll on the athletes over the course of a game or training session.

Over recent years the applications of GPS and inertial sensors in sport has been adopted with significant interest being placed on athlete performance and workload monitoring. GPS devices by design track only activities associated with locomotion. Due to satellite transmission and calculation errors, GPS typically increase in error with dynamic movements, including changes of speed and direction. Considering that a large portion of workload in many sports is not locomotion based, the use of GPS based systems can be limited.

Several papers \cite{1, 2} have investigated using inertial sensors as a means of data collection relating to workload. These papers report a strong correlation between the stride rates obtained from inertial sensors and running speed, indicating that inertial sensors are a viable means of measuring basic performance indicators.

Continuing investigations with inertial sensors in sport, recent studies by Kelly, et al. \cite{3} have examined the possibility of using a Neural Network (NN) approach to automatically detect tackles in Rugby Union from the inertial sensor data. This approach involved the implementation of two NN models, one to find all the collisions in a set of impacts and another to find all the tackles in a set of collisions. When reporting on the accuracy of this system high levels of precision (0.958) and recall (0.933) were obtained indicating that the system was able to correctly identify the vast majority of tackles. Kelly’s, NN approach demonstrated the possibility of identifying collision events from inertial data, prompting for further investigation into the physical elements that separate collision types.
A solution is proposed to extend on the feasibility shown by the NN solution by accurately and automatically detecting tackles and contentions through the classification of key inertial indicators. This solution would implement an athlete time series analysis toolbox [4] to explore the inertial sensor data and derive a set of conditions to define contention and then apply these definitions as an automatic detection method.

By defining the conditions that represent contention, and its various forms, an increased knowledge into the forces the players experience can be achieved leading to a greater understanding of the physical workloads that occur. This research helps to develop on current accelerometer processing techniques to further improve the monitoring of performance as well as contribute towards injury prevention and analysis.

REFERENCES


A Wearable System for Real Time Swimmers Feedback Based on Visible Light Communication

Rabee M. Hagem, David V. Thiel, Steven G. O’Keefe and Thomas Fickenscher

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ABSTRACT

The use of movement sensors in swimming performance can be used to improve injury recovery and training progress. Swimmers and coaches have been dependent on visual, video processing or sensors and all require post processing. Real time feedback is very useful in swimming because some aspects of swimming are opposite to human intuition for example, an increase stroke rate can reduce velocity because of poor technique. A real time system can provide swimmers with information during swimming in order to adjust instantly. A movement sensor can provide stroke rate, stroke length and the velocity of a swimmer [1-4]. Such a system can be used during training in order for a swimmer to find the most effective techniques to improve performance. The real time feedback system can also help coaches to identify minor improvements not immediately apparent from a visual inspection. They can check later that the swimmer did what was asked.

The main aim of this project was to establish an optical wireless communication link for swimming applications to give real time feedback about their swim to swimmers while swimming.

As swimmers are located relatively close to the surface of the water, arm and leg movement can generate a significant number of air bubbles. Total internal reflection from the surface and attenuation due to bubbles presents a major problem for communications both below and above the water. The final system includes a wrist mounted accelerometer, processing unit and optical transmitter. The receiver is mounted on the goggles with a multi-coloured heads-up display. The system design challenges included: communication type, optical transmitter, optical receiver, optical wavelength, modulation type, bubbles effect, strong background light, link budget and electronics requirements. The look angle for the transmitter, swim style and swimmer competence all impact on the effectiveness of the link. Most of these challenges were solved by making the unit self-adjusting for maximum communications connect time.
The additional requirements for the device were wearability to prevent disturbance to normal swimming and more than 1m transmission distance (head to wrist). The data is recorded and processed at the transmitter and useful information sent to the receiver (eg. stroke rate, lap rate, stroke length, swimmer velocity and swimming style). In this project, experiments were conducted in air and water in order to check the reliability and the validity of the system [5]. Acceleration data was processed in real time in order to extract useful information including mainly the stroke rate, however the stroke length, swim velocity, lap times etc can also be extracted. The feasibility of the system has been demonstrated. The system designed, implemented and tested in this project can be used as a real time feedback in different sports.

REFERENCES


Aquatic communications for real time networks

Daniel A. James\textsuperscript{1,3,4}, Sean Kelly\textsuperscript{1}, Amin Abbosh\textsuperscript{2}, David V. Thiel\textsuperscript{1}

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ABSTRACT

The use of mobile sensor platforms to monitor an athlete’s performance in the aquatic environment is well established\cite{1}. Recent developments\cite{2} have realised the possibility and advantages of near real time communications between body worn sensors on the athlete with remote and pool side display and storage devices. In this environment the synchronisation of multiple devices and data sources, such as video, is deemed attractive. Recent developments in data bases suitable for time series data, together with cloud based systems have the potential for allow seamless integration of data in terrestrial applications\cite{3}. However in the aquatic environment the lack of real time communications, principally through the use of radio communications is problematic. This is primarily due to adsorption and dielectric effects.

In this paper a recently developed antenna\cite{4} is tested for effectiveness in the near air-water interface. The results demonstrate that satisfactory transmission can be achieved that is sufficiently robust for adoption in wearable aquatic devices. An ultra wideband corrugated antenna has been constructed for testing in an aquatic environment. Simulations of the antenna design indicate performance sufficient to operate at the band assigned for the wireless monitoring system when placed in three operating environments: Free-space, underwater, and at the free space/ water interface. The antenna was found to be a potential solution to one that has plagued the sports science community, it operates at depths to 20cm and has a range suitable for the pool side environment. Future testing with sensor data and use in the training environment in ongoing.
REFERENCES


Towards Dynamic Visualisation: Interactive Analysis via the Cloud

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ABSTRACT

Inertial sensor technologies are quickly becoming more affordable, unobtrusive and ubiquitous, leading to an influx of data from multi-sensor configurations. By improving existing methods of analysis, the process of identifying and extracting useful patterns from this data can be facilitated. Extracted patterns may be used as direct feedback for athletes, or as input for dynamic visualisation systems [1].

Within the Centre for Wireless Monitoring and Applications (CWMA) at Griffith University, sporting data is often analysed via MATLAB, a numerical computation engine that allows users to design algorithms in the form of scripts, and visualise their output using table-, plot-, graph- and surface-based data representation templates. Depending on the nature of the data, these algorithms can require significant guesswork and estimation in the design process [2], while also demanding large amounts of storage space and processing time to execute them [3].

Through the use of modern server and web technologies, it is possible to delegate this type of data analysis to a cloud-based online system. The entire process, from data import to pattern extraction, can be performed by a centralised but internally distributed network of server computers. Ancillary client software can subsequently provide the user with a discrete, customisable interface for manipulating and refining algorithms interactively [1][4].

MATLAB-centric data analysis within the CWMA tends to follow a rather consistent pattern: (1) develop a script to produce visual output from the data (tables, plots, graphs and/or surfaces) by estimation, thresholding and regression; (2) run the script and review the generated visual representations; (3) adjust assumptions and refine the script to suit; and (4) repeat steps 2 and 3 frequently, and perform major revisions occasionally. Alternatively, in the proposed environment, the developer would avoid...
estimation in step 1, and instead flag regions of uncertainty to be adjusted and refined in step 2. The user may still choose to perform steps 3 and 4, but will also have the ability to manipulate the script interactively through auto-generated instruments. These instruments, beginning with sliders, buttons and viewing tools, will apply minor changes to the script and re-execute it, thereby allowing visual representations to appear dynamic from the user’s perspective. It is expected that the use of these instruments could replace direct manipulation of script code in some circumstances.

As an example of use, consider a supervised training session in which a freestyle swimmer has one triaxial gyroscope attached to each wrist during their time in the pool. Each gyroscope records 100 samples per second of angular rotation (Coriolis force component), and there are no specific reference points indicating the beginning or end of each lap. The sampled waveforms are likely to be affected by background noise, cumulative zero drift, variance in technique and fatigue levels. The supervisor uploads the data for analysis, and can visually observe groups (laps) of somewhat cyclic motions (strokes) within it. They decide to generate a ‘wave-of-best-fit’ for each lap by approximating known influences and including different types of unknown influence quantities. All contributing factors are adjustable, and can be overlaid onto the recorded data for fine-tuning. If successful, these waveforms can be standardised across multiple sessions and/or athletes, and provide a quantitative metric for perceiving long-term change.

While it is difficult to predict the efficacy of this technique in its early stages, the importance of developing next-generation tools can be seen by our dependence on those that exist today. It is hoped that the development of these new techniques will eventually facilitate a better understanding of the characteristics and patterns that influence sporting performance.

REFERENCES


Sensing for Sport: A Smart Phone Alternative

Mitchell W. McCarthy\textsuperscript{1,3}, Daniel A. James\textsuperscript{1,2,3}, David D. Rowlands\textsuperscript{1,3}

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ABSTRACT

An area of interest in sports monitoring is inertial sensor technology, with sports scientists, coaches and athletes currently having the option of using custom hardware or off-the-shelf dedicated sensor packages. Custom hardware has the advantage of being designed to meet requirements specific to an application at significant cost of resources including money, time and personnel. Purchasing commercial devices is generally a faster, cheaper option, but users are limited to the hardware provided by the manufacturers. While either of these options may be suitable for some applications, smartphones offer an alternative through low cost, ubiquity and flexibility.

A persistent issue with commercial sensors is that of non-standard design among manufacturers. With several communication protocols available (Bluetooth, Wi-Fi, proprietary) and no clearly defined data formats, interoperability between different manufacturer devices is practically non-existent. Another issue that has been well documented is the high power consumption of these protocols relative to the amount of data being transmitted [1]. The most recent Bluetooth hardware and ANT (a proprietary low power, sensor oriented protocol) attempt to address this problem. However, they also require specific hardware and add to the number of protocols available for implementation.

Smartphones offer a low cost generic solution and similar to off-the-shelf packages, remove the costs of design and development. They contain a variety of common sensing devices including accelerometers and GPS and have seen previous success in sports applications [2]. By offering communications hardware for several protocols, they also provide flexibility through data collection from external sensor devices for local processing and storage [3]. In addition, data collected on the phone can be uploaded to external devices or servers which may provide more processing, analysis and storage capabilities [4].
The potential use of smartphones for monitoring applications is faced with some challenges. As with many wireless devices battery capacity is a major issue, but can be partially alleviated through careful management of the hardware and software [5]. Secondly, the embedded sensors may not be as accurate as dedicated devices for some applications. However, they are still capable of showing overall trends and patterns. It is envisaged that as smartphone technology evolves, more advanced sensors will be included and power efficiency will improve.

Each of the options has its benefits and disadvantages and the choice will depend on the nature of the application. Custom hardware can be costly but allows greater flexibility and application specific design while off-the-shelf sensor packages provide a range of low-cost devices for immediate implementation. Smartphones have proven to be a viable alternative in sports monitoring where reduced cost is necessary while still maintaining a degree of flexibility.

REFERENCES


Improving the communication range of a body-worn Wi-Fi wireless sensor

Mohammad V. Varnoosfaderani, Juniwei Lu and David V. Thiel

Centre for Wireless Monitoring and Applications, Griffith University, Nathan, Qld, Australia

ABSTRACT

In recent years, interest in body-worn wireless devices has increased in sports to create a feedback path of performance information for coaches to improve the performance of athletes. One of the major problems in body worn wireless devices is the detrimental effect of the human body on antenna performance which causes a significant decrease in the signal strength and so a major decrease in the communications range. The human body affects the performance of an antenna through a change in the input impedance of the antenna resulting in impedance mismatch, and radio wave absorption in the body. The Centre for Wireless Monitoring and Applications at Griffith University has developed small wireless sensor nodes to monitor human movement in sport during both training and match play [1]. The sports employing these techniques include football, swimming, tennis, running, field hockey, boxing and many others. One device (z-core [2]) consists of a 3 axis accelerometer, a three axis gyroscope, Wi-Fi connectivity (2.45 GHz), a USB rechargeable battery and a colored LED display. The device is housed in a robust rectangular plastic case measuring 50mm x 30 mm x 8 mm. The device is usually worn in a fabric band with Velcro fastening with a specially designed pouch to allow simple installation before and removal after use (Fig 1). The double layered FR4 printed circuit board in the sensor includes a standard design [3] meander line monopole antenna. While the free space range exceeds 20 m, the range when worn is reduced to less than 3 m. The decrease in range is attributed to the effect of the human body in both changing the resonant frequency of the antenna, a change in the radiation pattern, and the absorption of the radiation. A method proposed to improve the performance of the wireless sensor by adding a parasitic element next to the antenna of the sensor. In this way, a kind of wearable antenna with simple connectivity and without any connector has been introduced. The parasitic element is electromagnetically coupling to the active antenna in the sensor which also affects the input impedance of the antenna and changes the resonance frequency. It is possible to compensate the effects of shift in the resonant frequency which has been created because of the body. A step
impedance resonator (H- shape) has been chosen as the parasitic element and proven to improve the radio range.

REFERENCES


Figure 1: Wifi accelerometer worn in the armband. The parasitic “H” shaped conductor reduces the effect of the body and so improved the radio range of the sensor.
A fully instrumented and dynamically adjustable stationary bike for optimisation of biomechanical efficiency.

Chris Balser, Stewart Williams.

ABSTRACT

Professional bicycle fitting services are utilized to improve comfort, efficiency and power when cycling. Improvements in these areas are documented for casual and professional cyclists, subject to various fitting methodologies [1, 2, 6].

Optimal cycling position is defined by subjective (comfort) and objective (biomechanics, kinematics, power, torque) measures, that emphasize balance, symmetry, efficiency and power [1,4].

Comprehensive fitting addresses both postural and phasic conditions inherent to cycling. Postural considerations include contact points, weight distribution and aerodynamics; phasic aspects relate to biomechanics, muscle function, efficiency and power [3].

Protocols are either dynamic (working with person on bike or fit-bike) or static (through a combination of limb measures, ROM and physical assessments), accompanied by whatever technology is preferred to measure and document the procedure and outcome[1].

Dynamic fitting approaches are considered superior to static for accurate, positive outcomes, due to the variability in subject morphology, flexibility, and history (e.g. sports, medical, and lifestyle)[1]. Proper application requires numerous adjustments in positioning, with difficulty compounded by the change in proprioception inherent to mounting/dismounting the bicycle/fit bike between trials.

Biobike is a fully automated, dynamic fitting system, designed to identify and refine the acceptable range for saddle, handlebar and pedal positioning to a range of +/- 2mm within subjective and objective criteria, without requiring the mount/dismount procedure.

Efficiency is determined by the integrated “i-Cranks” and software.

iCranks are fixed/ non-fixed crank arms with accompanying ergometers, capable of measure the function or each leg without residual contra lateral pedal forces [7]
Biobike software incorporates tools for biofeedback training, to reduce counterproductive pedaling and/or correct muscle imbalances.

REFERENCES


Semi-Automated Skills Assessment for Junior Field Hockey Players

Sophie Nottle, David V. Thiel

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ABSTRACT

In junior hockey, a large number of players are assessed for their capacity to play at a regional representative level. With a potential cohort of 100 players in each age group, the team selection process of 15-20 players is very demanding on coaches. Commonly, observational notes are made of each player through a series of drills and practice games. In practice games with positional play, the opportunities afforded players is quite varied and some talented players might be overlooked. Without measurement technology, no additional quantitative information about skill level can be obtained. Such information can augment the overall assessment of playing ability – of course skills assessment alone is not sufficient and players must still be assessed on match play “intelligence” and ‘perception”. This will include tactical positional play, running speed, fitness etc. The application of measurement technology in field hockey has been restricted to GPS positioning and standard fitness tests. Recently, some preliminary research with stick mounted accelerometers has been reported by Griffith University researchers.

Following a series of stick acceleration measurements with novice, junior and elite players, a series of single person hockey drills have proved successful in categorizing skill level in players [1 – 3]. The four drills require the attachment of an accelerometer logging unit on the player’s stick. The player is then required to repeat each drill ten times or to continue the activity for 15 seconds. The mean time between hits is determined. In general, the shorter the time between hits, the higher the skill level of the player. Each drill was designed to resemble activities commonly used in training. The four drills were:

The modified Chapman ball control test [1] (the player is required to continue to hit the ball within a small area – the control box over a 15 second period). No directional control is required. This is an extension of the Chapman ball control test [4].

The 2 hits and flick drill requires the player to move the ball across the front of the player and then push the ball forward. At the start position, a
stationary ball is placed on the right and left sides of the player to assess forehand and reverse stick control.

The trap – hit drill requires the player to control an incoming rolling ball with one hit and then drive the ball forward. The incoming ball direction is varied between forehand and reverse stick positions.

The bounce drill requires the player to hit the ball vertically with precision and control.

The test sequence lasts less than 5 minutes and can be conducted during a training session. An automated analysis program allows rapid feedback of skill level to the player. The technique is now sufficiently robust that it can be used routinely in hockey skills assessment.

REFERENCES


Video Digitising Interface for Monitoring Upper Arm and Forearm Rotation of Cricket Bowlers

Hugo G. Espinosa¹, Daniel A. James¹,²,³ and Andrew Wixted¹

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ABSTRACT

In many sports, sports scientists and coaches are interested in defining the key techniques of elite athletes. Athletes are monitored with inertial sensors and high speed video and it is necessary to merge this data to extract the parameters of elite technique. The upper arm and forearm rotations are critical in a number of sports. Monitoring this rotation is essential for the enhancement of the athlete’s performance, since it contributes to the speed of the serve in tennis [1], to the propulsion of swimmers [2] and to the fast bowling in cricket [3,4], among others. This study investigates the digitising and merging of video and sensor data for the cricket bowling arm action.

In recent years new techniques have been developed for monitoring upper arm and forearm rotations. Inertial sensors (accelerometers and gyroscopes) are being widely used in the sports community, the sensors respond to minute changes in inertia in the linear and radial directions [5]. Vicon’s standard plug-in-gait together with geometric calculations and a mapping of the space is also used to calculate these rotations [1].

This work presents a video digitising user interface for monitoring upper arm and forearm rotations of cricket bowlers, by using a marker-based system that pointed at the bowler’s wrist and elbow from every high speed motion video frame. Associated software read the sensors and automatically found the ‘overs’ in the sensor data. This allowed the quick matching of video and sensor inputs for bowling deliveries. To fine tune the relationship between the sensors and the video data, by digitising the video, virtual accelerometer data was produced which could be used to align the video with the sensors.

The video interface was developed using a programmatic GUI construction in Matlab environment. The interface allowed the user to enter
manually the number of frame increments in normal and slow speed, the start and stop tagging frames and other features such as ball release frame, crease coordinates and stump location. Captured data points could be reviewed and edited prior to saving in a *mat* format along with the file and path names and the other data marked in the video.

The advantage of this tool relies on its user-friendly simplicity and low cost since no external device is needed for the marking process. With few modifications the tool can be extended and adapted to any other sport. The built-in code has been optimized in order to process large sensor data and large high speed motion videos [6].

Figure 1a shows a snapshot of the video digitising interface and Figure 1b shows the elbow and wrist data interpolated using high-order polynomial fitting.

![Figure 1a](image1.png) ![Figure 1b](image2.png)

Figure 1. (a) Video digitizing interface snapshot (b) High-order polynomial interpolation of elbow and wrist data.

**REFERENCES**


Architectures for distance education of Athletes

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ABSTRACT

The improvement of athletes through coaching is critical for their development [1, 2]. Any athlete unable to access coaching due to distance or lack of personnel can be disadvantaged. Competitive sports such as cross country mountain bike riding contain sub-elite athletes who want to improve and progress to the elite level, but are unable to do so due lack of coaching support. This is a disadvantage for the entire sport since the athlete’s skills and training methods are not being supervised. The web can be used to help this problem by giving athletes access to a specially designed coaching program without a coach being physically present. Therefore a “virtual coach” web site was created.

The design encompassed the development of a coaching program using a web based interface for use on popular desktop systems and mobile devices. Development aimed at creating a simplistic design that was easy to understand and navigate. The architecture aimed for flexible content delivery together with the ability to collect metrics about the websites usage patterns.

Virtual Coach was designed for flexibility, stability and security. The site content was provided using Apache HTTP Server (Apache) as the web server on a commercial host. Apache was chosen due to its efficiency, stability, and the fact that it is the most widely used web server [3]. Using Apache, communication from users to the virtual coach system is secured with SSL/TLS Strong Encryption (HTTPS). Content served by Apache is written in the HyperText Markup Language (HTML) which is understood by all web browsers. It specifies how plain text should be displayed when drawing web pages. HTML requires considerable coding for sites with many pages of content. High amounts of HTML can be reduced and the site made more interesting by using dynamic content. Dynamic content is when the web server generates the HTML to display required information; this can be unique for each user or change when specific conditions are met. The
dynamic content for virtual coach is generated on the server using PHP: Hypertext Preprocessor (PHP). PHP is a server-side scripting language capable of generating dynamic web pages. Using PHP, the virtual coach system generates web pages from a common template keeping the layout but changing the content. This saves development time by reducing the amount of HTML coding and greatly simplifying system wide changes. PHP is also able to communicate with MySQL which is a database server used to securely store all required information. MySQL can perform unique queries from information obtaining specific results speeding up data analysis.

The content of the web pages were developed by an experienced mountain biking coach and was aimed to provide workouts and training exercises which were provided in separate modules. The athlete would progress through each module in a time frame defined by the coach. Within each module, the content was split into various levels based on the user’s skill and fitness. The modular format allowed for sections to be completed and fitness to be assessed for each module which would determine the next module to be attempted. This provided motivation for the athlete to complete the modules and progress in fitness level.

A field test of the virtual coach system was conducted using 50 cross country mountain bike riders. Participants were given a unique login and their site usage was tracked and logged by the system. Logged data included login times; page views; time spent per page and per section. The system also recorded fitness scores and gave feedback based upon the fitness scores. Data saved by the system allowed the comparison of user adherence and fitness results as well as personal improvements for each athlete.

The virtual coach system was found to provide an easy to use website that athletes could access when it suited their needs. This could be in the home environment for remotely located users or in the field from a mobile device. Overall the virtual coach was found to be an effective method of providing coaching support to the athletes without the need for a coach to be physically present.

REFERENCES


An effective method for monitoring swimmers with a shoulder injury

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ABSTRACT

Swimming is seen as a low impact activity or sport without a high risk of injury. However, shoulder injuries are reported to occur in 27-87% of swimmers [1] with both competitive and casual swimmers experiencing interruptions to training, exercise, and performance. Furthermore, many casual swimmers experience shoulder injuries and this restricts their activity in what is sometimes the only cardiovascular exercise in which they can participate. Monitoring shoulder muscular activity during swimming is difficult and by traditional means, impossible while someone is actually swimming. Inertial sensor technology developed at Griffith University’s Centre for Wireless Monitoring and Applications provides a tool for in-water assessment. The sensors have been proven to be accurate at measuring human movement patterns in aquatic environments [2, 3].

Shoulder Pathology - Shoulder impingement, and associated rotator cuff disease or tendinopathy which can progress to disabling rotator cuff tears are the most common cause of shoulder pain in swimmers. Movement dysfunctions involving the scapula and humerus which reduce the subacromial space are suggested to contribute to the development, or prolongation of these painful conditions. When the scapula is placed in an excessively upward and forward position (e.g. arm glide in freestyle) during elevation of the arm it is thought that the tendons of the rotator cuff are caught between the humerus and acromion resulting in continual tendon trauma [4].

Scapula movement has been investigated on numerous occasions including a review by Ludewig and Reynolds [5]. Studies either used an electromagnetic or an optical motion capture system. This requires surface
sensors with long wires attached to these sensors potentially limiting the shoulder freedom of motion. Furthermore, both video and infrared capture is time consuming, expensive, and labour intensive [6]. There is no evidence of water monitoring of scapula motion in the literature. The shoulders are usually at the air-water interface often with occlusion from bubbles and wash.

The purpose of this pilot study was a proof of concept to determine whether inertial sensor technology could detect movement of the scapula. A male participant having one healthy shoulder and one shoulder with signs of subacromial impingement was assessed. An inertial sensor was positioned over the spine of both scapulae. A video camera was positioned facing the participants back. This was to capture movement of the scapulae during these arm actions while the sensors were tracking and the two were synchronised for assessment [7]. He was asked to perform shoulder flexion and abduction both loaded and unloaded.

Arm elevation could be clearly identified from the inertial sensor data and fusion of inertial sensor and video data provided information about the movement of the scapula in response to gleno-humeral elevation. Additionally, clear differences could be seen between the healthy and pathological shoulders.

This pilot demonstrated the ability of a microsensor to detect scapular motion. Additionally, this study has shown visible differences in data output of the two shoulders. Full validation is required and should be carried out both on dry land and in-water. Successful outcomes would provide a multipurpose device that would provide a monitoring tool for professionals monitoring shoulder injury.

REFERENCES


Using Sensor Technology to Assess Health and Sport Benefits of Trail Bike Riding and Other Off-Road Motorcycling Activities: A Research Proposal

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ABSTRACT

This presentation describes a proposal to investigate how trail bike riding and other off-road motorcycle activities impact on physical fitness, cognitive abilities, mental, social and family health. We have developed a technology capable of equipping a motorcycle and rider with inertial sensors which are designed to continuously acquire data to monitor the forces operating on the rider and the motorcycle. These light-weight sensors are approx. 5 cm by 3cm, and assess both linear and angular acceleration. These “wearable nodes” can be combined into a synchronised network of several sensors and a video of the rider either from a camera on the helmet or track side. The device is controlled using a microcontroller with a scheduler-based operating system to conserve power and is custom-packaged with a user interface and USB port that is fully waterproof. Together these sensors enable complex body dynamics to be measured and related back to motions of the motorcycle and characteristics of the track (for example cornering and jumps). Our prior results demonstrate the usefulness and feasibility for such devices in the preparation of athletes. The developed system demonstrates how our analysis techniques can be used to facilitate the primary goals of training and athlete performance both in the field interventions and for long term developmental planning.

The importance of the advent of this new technology for off-road motorcycling and related sports is in the objective measures that can be taken of the physical demands of these sports. We propose to undertake a research program that will relate these sensor data to both physical and cognitive benefits of engaging in these sports and hence the potential health and well-being benefits. Standardized tests of physical fitness and cognitive processing...
will be used in a series of studies that will compare elite and recreational riders to control groups and also examine changes in these measures in a group of riders monitored over an extended period.
FPGA: A different paradigm for sports monitoring hardware

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ABSTRACT

Multi-sensor platforms have been applied to many sports to examine different aspects of an athlete’s performance. Inertial sensors such as accelerometers and gyroscopes are now routinely being used to quantify an athlete’s movements and hence obtain a useful signature of the movement under examination \cite{1,2}. These sensor platforms contain both software and hardware components. The software component typically takes two parts; the software to run on the hardware itself (firmware), and the software to access the data. The software can be easily modified to change the operation but is limited to the configuration of the hardware platform. The hardware components typically consists of a set of sensor (GPS, inertial sensors etc), a set of communications subsystems (USB, serial, WiFi), storage subsystems (memory card etc), interface subsystems (buttons, LEDs, screens etc), a microcontroller, and a power source (battery). This requires a Printed Circuit Board (PCB) to be designed, manufactured, and tested. If any changes or upgrades are required then this process needs to be repeated which means that it is not resource effective to create new hardware for different monitoring applications. Another issue is that the analysis of the data is limited to the speed and power usage of the microcontroller so complex algorithms etc are not commonly performed on the hardware but post processed later. These hardware platforms can either be custom designed allowing flexibility in the initial design but using a lot of resources, or bought as an off the shelf component with limited choice of sensors and other subsystems all of which reduce the possibility to target different monitoring situations.

A different paradigm is to use a configurable hardware platform which can be changed for different applications and can allow the creation of different digital hardware circuits to perform analysis such as hardware based Fast Fourier Transforms etc. This configurable hardware system consists of a single PCB that contains the subsystems connected to a configurable unit that
would act like different circuits as required by the different monitoring applications.

A Field Programmable Gate Array (FPGAs) is an integrated circuit that contains configurable logic blocks and interconnects which can be programmed to create digital circuits. This means that a circuit description can be created in software and downloaded to the FPGA acting as the configurable unit described in the platform given earlier. Typically the FPGA is physically small but allows complex circuits to be implemented. FPGAs, such as the Spartan 3, can implement microcontrollers or multiple parallel microcontrollers, sensor controllers, and hardware signal analysis components [3]. Firmware can then be implemented on the microcontroller to control the hardware. This gives the possibility to create targeted monitoring systems for each new monitoring application without having to go through a PCB design, manufacture and testing process. The reduction in power usage (sleep modes etc), the increased density and affordability means that the FPGA is becoming a more viable option.

Overall, using FPGA in the hardware design can allow for the design of versatile platforms which can be individually configured and targeted for the different monitoring applications without the need for a new PCB manufacture process.

REFERENCES


Monitoring Athlete Workload: Combining Sensor Technologies in Field Team Sports

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ABSTRACT

The pressure on athletes to perform increases with the level of competition and thus great interest is placed on the monitoring of athlete workload. Technology used at the elite level in team sport is as diverse as the sports themselves, ranging from video analysis of competition to laboratory based strength tests. Sensor technologies are steadily working their way into elite competition as they provide information on athletes usually without inhibiting athlete performance during training and competition. The analysis of recorded athlete data is often limited by user understanding, interpretation and data volume. Very few studies have explored the common technologies in field based team sports and how these technologies can be combined to provide further information towards monitoring workload.

Historically, many sporting codes have been opposed to the use of technology at the elite level. In a general sense, the community perception of technology in sports is shifting with many sports now permitting the use of sensors to monitor workload in competition \cite{1, 2}. Two of the more common technologies in field based team sports, Global Positioning Systems (GPS) and Inertial Motion Units (IMU) are frequently becoming common at the elite level. With continuing advancements in technology, these devices are often being incorporated into single, athlete mounted units, however, the information they provide is often not being utilized to its full potential. This research proposes a method to improve workload monitoring by combining data provided by both GPS and IMU devices.

Global positioning data is typically comprised of a series of latitude and longitudinal samples calculated after triangulation from multiple visible satellites. By combining this data with time stamps for each sample, fundamental workload indicators including distance, speed and acceleration...
can be extracted. Neville et al [3] has developed further analysis techniques for processing GPS data to identify longitudinal workload analysis techniques including methods for monitoring fatigue and injury recovery. GPS devices are however limited by their required satellite connections as well as being limited to tracking activities where over-ground displacement can be determined. Previous research [4] has also discovered that GPS suffer from reduced accuracy during dynamic activities. By exploring the application of IMU devices, these limitations of GPS can potentially be reduced.

Inertial motion units (accelerometers, gyroscopes and magnetometers) provide information on athlete bearing, body rotations and impact forces, each of which can aid in monitoring athlete workloads. Unlike GPS, IMUs provide a more abstract method for monitoring physical limb or center of mass movements. Previous research [5] has explored the use of accelerometer force measurements for tracking athlete collision counts, and bouts of high intensity. On-going research [6] with accelerometer devices is exploring the possibility of extracting speed from elite level competition accelerometer data with promising results. These advancements in IMU data analysis methodologies create a baseline to expand on workload management tools by utilize both technologies.

GPS and IMU devices provide very unique perspectives on athlete workload monitoring. By combining both sensor platforms and their analysis techniques, the limitations of one sensor can be minimized using the strengths of the other, thus leading to increased accuracy of the collected data and improved methods for monitoring athlete workload.

REFERENCES


Innovating to grow sport: The wider context of innovation in sport

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ABSTRACT

Innovation is nothing new to sport, but represents everything that is ‘new’ and can facilitate a competitive advantage. Broadly defined, innovation is the introduction of a new idea or behaviour in the form of a technology, product, service, structure, system or process on to the market \cite{1,2}. Innovation is different to invention. It moves beyond the discovery of a new idea to solve a problem and instead focuses on the market introduction of that invention to end-users or consumers \cite{3}.

In the sport context, innovations that are solutions to a pre-identified problem or need are critical to developing sport and for maximising the experiences and performances of individuals and organisations. This paper argues that future innovation in sport should focus more on identifying individual and organisation needs for technology and management innovations (i.e., performance gap) to better facilitate enhanced sport experiences and performances at all levels.

Advances in sport technology are part of the growing global sports and recreation industry. At the individual level, technology innovation is changing the way that we practice and connect with sport. For instance, innovative uses of technology can help spread expert knowledge about best practice coaching through IPads and Smartphone apps thereby addressing the needs of recreational sport participants for more interactive experiences. Further, media and information technologies (e.g., high speed and infrared cameras) address the entertainment needs of the viewing public and provide vital information to coaches and officials.

At individual levels of \textit{elite} sport, technology innovation is applied to sports science, sports medicine, sports surgery, sports rehabilitation, and
sports coaching and is integral to athlete development and performance. For instance, wireless tracking and wearable sensors provide quality feedback for performance analysis and monitoring, and enhance training and competition outcomes.

Similarly, at the organisational level of sport, technology innovation is commonly acknowledged as a source of competitive advantage. Technology is used to grow consumer interest and increase funding for sport (e.g., through improved sport coverage and broadcasting), improve sport quality (e.g., through adjudication and officiating), regulate sport (e.g., through doping detection), and improve access to sport experiences (e.g., through advances in sport safety).

Yet, management innovation in sport is also gathering momentum. Management innovation refers to the introduction of new practices, processes, techniques or organizational structures that are “more systemic and difficult to imitate than technological innovations” and can therefore provide a distinct competitive advantage. Management innovations are an important source of value creation and underpin the leadership and performance frameworks of successful sport organisations. For instance, organisations that adopt new practices and processes can enhance the efficiency and effectiveness of their operations and address performance gaps. In many cases, technology may act as an enabler of management innovations.

Yet, anecdotal evidence suggests that approaches to identify a technology or management need are often adhoc and not well structured. That is, innovative ‘solutions’ are often developed before a problem has been identified; commonly referred to as ‘solutions in search of a problem’. Innovations that address pre-identified needs have a greater capacity to grow sport. We suggest that sport can effectively address performance gaps and create competitive advantage by conducting need assessments. Future innovation in sport should focus more on identifying individual and organisation needs for technology and management innovations to enhance sport experiences and performances at all levels.

REFERENCES


A Novel Field Test of Eccentric Hamstring Strength: A Reliability Study

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ABSTRACT

Introduction and purpose: Hamstring strain injuries (HSIs) and reinjuries are the most common injury in sport. Eccentric knee flexor weakness is a major modifiable risk factor for future HSI, however there is a lack of accessible methodologies to assess this strength quality. The purpose of this study was 1) to determine if a novel device, designed to measure eccentric knee flexor strength via the Nordic hamstring exercise (NHE), displays acceptable test-retest reliability and 2) to determine normative values for eccentric knee flexor strength derived from the experimental device in healthy males.

Methods: The novel device employed in the current study consists of padded braces used to secure the ankles with load cells located directly underneath and a base furnished with foam padding to provide cushion support for the knees. During the eccentric portion of the NHE the lower leg pulls up against the braces with the force transmitted axially and recorded by the load cells. Thirty recreationally active males (22.5 ± 2.3 years; 1.81 ± 0.06m; 80.5 ± 8.5kg) completed NHEs and had their strength measured on the device on two separate occasions. Intraclass correlation coefficients (ICC), typical error (TE) and typical error as a coefficient of variation (%TE) were established. Normative strength data was determined using the most reliable measurement.

Results: The device displayed high to moderate reliability (ICC = 0.85 to 0.90; TE = 21.7N to 27.5N; %TE = 5.8 to 8.5). Normative eccentric strength for the left (344.7±61.1N) and right (361.2±65.1) limbs were determined in healthy males.

Conclusions: The experimental device, using load cell technology, offers a reliable method to determine eccentric knee flexor strength in the field. This device has the potential to increase the accessibility of eccentric knee flexor strength assessments to athletes and clinicians alike.
Swimming Posture Device

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ABSTRACT

Performance enhancing bodysuits were banned from competitive swimming in 2010, after having contributed to over 250 world records being broken in the preceding two years [1]. These bodysuits were seen to have primarily influenced core stability and posture [2].

In the absence of bodysuits, many swimmers’ performances have regressed, suggesting there is a gap in training programs for posture as a component of performance.

Design - From this need, a device has been developed for promoting correct alignment while swimming. The Swimming Posture Device is worn around the waist during training or pre-race warm-up to encourage the user to achieve and maintain a straightened spine, which is considered ideal posture in swimming [3]. Tactile feedback is used to communicate to the swimmer when this position is lost, as pressure along the back begins to become uneven.

The device is constructed of two Polycarbonate panels, a smaller one worn on the stomach and a larger one worn running along the spine. A belt secures these members around the waist and distributes pressure across the stomach and back. Dual-ladderlock buckles are used to fasten and tighten the belt.

Feedback - Both swimmers and coaches of an elite level have trialled the device, and have provided anecdotal feedback. Common feedback has suggested many swimmers would most often use the device as a final preparation tool in warm-up before racing, given its ability to provide instant feedback. Likewise, coaches have suggested that using the device as a calibrator during training sessions, as athletes fatigue, would be desirable.

From this feedback, there does appear to be a need for such a device, and at least some demand from the swimming market.
REFERENCES


