8th Conference of the International Sports Engineering Association (ISEA)

Design of an end-user centric information interface from data-rich performance analysis tools in elite swimming

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Abstract

The acceptance of novel performance analysis tools in any sporting domain is heavily dependent on the perceived effectiveness determined by the user type. The extent to which these varied needs can be captured and the flexibility within a systems design is investigated within the research presented in this paper through the application of conceptual enterprise models based upon the Computer Integrated Manufacturing Open System Architecture (CIMOSA) modelling framework. The CIMOSA cube has been used to accommodate a generic design that can be adapted into a swimming specific model, the aim being to develop Human Machine Interfaces (HMI’s) that can be simplified, scaled and reused within numerous sporting domains by formally modelling stakeholder requirements.

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Keywords: Human Machine Interaction, swimming, user modelling

1. Introduction

With the recognition of the global social, economic and environmental impact of sport comes the requirement to improve sporting performance analysis methods, which in turn has led to increased demands on the capabilities of technological solutions. Within any sporting domain, assessing functional ability is crucial for the analysis and guidance in athletic sports [1]. This is highlighted in swimming where it is suggested that detailed quantitative information regarding technique is lacking, mainly due to the aquatic environment [2]. A majority of research has focused on single elements that may influence performance; stroke analysis, arm coordination [3-6] and fatigue identification [7&8]. Emerging technologies look at using non-encumbering, swimmer-worn 'nodes' to monitor performance using sensors such as accelerometers [9-11]. The development of a wireless sensor node as part of a
component-based system at Loughborough University, aims to collect multiple swimming parameters (acceleration, force and vision based data) to display in real time and store for further analysis. The current reliance on manual notation and repeated input to databases in order to correlate such data from separate analysis systems is not only time consuming but susceptible to human error and subjective judgment. Creating an interface that can combine such data and display it to a variety of users in a simplistic yet intuitive way continues to be a challenge to system developers. The importance and development of a Graphical User Interface (GUI) is a primary focus of the research presented in this paper. A GUI is the convergence point for the user and capability set of the system. A system is somewhat redundant if the user is able to perform a number of complex operations, yet cannot access useful or meaningful results. A process methodology is suggested using enterprise modelling; a useful tool for anticipating and managing change [12], to develop a flexible GUI that displays the capability of the wireless sensor with the scope to integrate force and vision-based systems. For the purpose of this paper, free swimming was the exemplar to demonstrate the proposed methodology.

2. Proposed framework methodology: The CIMOSA cube

Modelling a system effectively is complex, more so in the initial stages of development when required information may be lacking [13]. Flexibility of the framework is crucial in a sporting domain where certain needs cannot be identified until sufficient data has been collected and analysed. Figure 1 illustrates the flexibility of the CIMOSA cube in considering the design of an interface from a general design (such as a wireless system interface), partial (a sports monitoring wireless interface) to a particular design (a swimming monitoring wireless interface). Within the CIMOSA structure there is a set of four different modelling views: function, information, resource and organisation. Being able to break down the structure of an enterprise into these categories enables each aspect of the enterprise to be included, creating a detailed overview that accommodates change [14-16]. The proposed methodology follows the CIMOSA cube path illustrated in Figure 1 (steps 1-4), where each is explained and applied to the wireless sensor swimming interface. The flexibility of the cube allows for consideration of different user types; general and system users, to be analysed from three design perspectives; generic, partial and particular. Generic design creates a basic interface applicable to many domains in industry that require a sensor based display. Partial design specifies the interface to the sporting domain alone, in which the display must accommodate athlete parameters and profiles, whilst particular design is specific to one sport, in this case swimming, where the needs of a swimmer are considered.

Fig 1: The CIMOSA cube and proposed methodology path
2.1 Step 1: User identification and Thematic analysis

Thematic analysis is conducted at the partial and particular levels where the design becomes user focused, i.e the user requirements of athletes across numerous sporting domains at the partial level and those of swimmers at the particular level. The generic and partial design can then be used as a reference architecture, in this case an interface design that accommodate the needs of all athletes, leaving only the particular elements to be reassessed in relation to the demands of the sport. It is most useful for system developers to focus on the reference architecture so that the system needs (identified in Table 1) can be implemented across domains. Table 1 illustrates the identification of general and system users, thematic analysis of each conducted through interview and qualitative techniques and subsequent ranking of the requirements. This process is fundamental in the generic to particular design at the requirements level.

2.2 Step 2: Domain classification

The next step is the transition to the specification level through classification of the partial domains that the interface should encompass. By grouping the needs according to the ‘themes’ the domains are automatically generated. Focusing on only one type of user is detrimental to the overall product, hence this method and subsequent domain classification is beneficial. The themes of highest priority that emerged from the thematic analysis involve the usability of the system, the intuitive nature of navigating around the solution and not being overwhelmed by data. In addition, reducing manual notation through the real time display and storage are identified as most important regarding the system functionality. Considering the needs identified in Table 1, domains were selected that encompassed the needs partially (a general sports monitoring interface) but also accommodated reapplication for the particular design (swimming monitoring interface). However, the domains only provide the basic framework for the partial design specification. In order to be applied to swimming, business process analysis must be used to fully examine what is required within the processes of each domain in the overall system.

Table 1. Thematic Analysis for partial requirements identification

<table>
<thead>
<tr>
<th>QUALITATIVE REQUIREMENTS</th>
<th>DOMAINS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Real time monitoring</td>
</tr>
<tr>
<td>Coach</td>
<td>X</td>
</tr>
<tr>
<td>Athlete</td>
<td>X</td>
</tr>
<tr>
<td>Sports scientist</td>
<td>X</td>
</tr>
<tr>
<td>Rec user</td>
<td>X</td>
</tr>
<tr>
<td>Develop</td>
<td>X</td>
</tr>
<tr>
<td>Maintain</td>
<td>X</td>
</tr>
</tbody>
</table>

| RANKING | 1 | 2 | 4 | 1 | 1 | 2 | 1 | 1 | 3 | 4 | 2 | 2 | 3 | 5 | 1 | 2 | 4 |
2.3 Step 3: Business process analysis

Each business process is analysed in terms of the resource, functional and information views as shown in Figure 2, transferring the system design fully from step two to step three, in which the specification is modelled at the particular level. Using this breakdown, the business processes within each swimming domain can be examined. In this example the business process of session selection has been chosen to illustrate the resultant breakdown. The system needs to accommodate choice of data display, in relation to the type of session the coach is implementing; whether starts, turns or free swimming are the focus. The session selection business process resides in the real time monitoring domain, the information available, the functional ability and resources needed are identified, aiding the final stage of the proposed methodology; how the user qualitative needs are then mapped onto the user interface.

2.4 Step 4: HMI tasks and widgets

HMI is a multidisciplinary subject, a range of expertise is required and a full review of the system requirements and capabilities need to be conducted. In completing the first three stages of the modelling path a detailed understanding of the particular system design was developed and the HMI diagrams were applied. Using a storyboard technique, the design of the interface is developed integrally with the user needs and the navigation through the system simplified. HMI widgets represent buttons the user interacts with that cause an ‘event’ within the program. This event may change the ‘state’ of the interface. The manner in which the swimming interface buttons relate to the primary needs of the users (based upon the highest ranking needs in Table 1) are shown in Figure 3. Storyboarding the interface design allows the developer to simplify and compare against the initial primary needs of the user.
As shown in Figure 3, the main functionality of the swimming monitoring system remains on the right hand side of the interface where most of the widgets are placed. This design can be applied at both the partial and particular level and allows the user to fulfill or access each of the highest ranking needs specified within ‘one click’ of a mouse. This fully demonstrates how this methodology develops an intuitive and simple interface as the needs of highest priority (considering all users in each domain) are chosen to be the most accessible. Considering the design from the general to the particular ensures it is re-configurable and reusable within other sporting domains.

3. Discussion:

A common mistake is to overwhelm the user with analytical functionality and performance data that requires a significant effort in order to derive parameters that are deemed relevant from coaching and sports science perspectives. In order to increase the acceptance of such new technology, reducing the amount of unnecessary work is crucial. This can only be achieved by conducting detailed analysis of both system and general needs so that design can progress from generic to particular level. Figure 4 demonstrates the final implementation stage in which the HMI storyboarding technique is applied to the software development. Although in the early stages, this interface is being designed using the proposed framework, the primary goal being to display and record multiple wireless node data in real time. In this example, the widget or ‘add graph’ button allows manipulation of the graphical display, whilst the ability to ‘tag’ events in a session has also been accommodated through the development of a flexible recording system, allowing the user to preview the tagged data, both within one click of the mouse. Mapping the storyboard interface onto the GUI fully has not been completed, it will continue to evolve as each swimming domain is investigated.
4. Conclusion

HMI is a key area in the development of novel advanced monitoring systems. How the user interacts with the GUI, how the system accommodates the user needs, matches the capability set of the technology and the resources available can only all be considered using a formal framework methodology. Conducting thematic analysis, extracting suitable domains and applying business process analysis, tackles issues within the sporting domain such as; data redundancy, overpopulating the data and uncertainty to monitoring parameters of interest. Storyboarding the interface encourages referral to the primary user needs, ensuring they remain integral at all design levels, improving the overall ‘navigational intuit’ of the system. The interface cannot be an afterthought, when developers become focused upon the capability set of new technology the user interaction does not remain to be the primary focus. Using this formal framework, such considerations have been addressed in order to increase the acceptance of novel technology. This framework has been applied at the general, partial and particular level, the next step will be to evaluate the remaining swimming business processes to further develop the GUI functionality at the implementation level.

Fig 4. Swimming interface under development using proposed framework
References