

TITLE OF THE INVENTION

WEARABLE COMPUTER FOR SPORTS PLAYERS

BACKGROUND OF THE INVENTIONField of the Invention

The present invention is directed to a wearable computer system and more particularly to a wearable computer for an athlete for sensing that the athlete or his/her athlete garment has been contacted in an illegal fashion during a sporting event.

Discussion of the Background

Many sports (e.g., soccer, American football, baseball and basketball) require one or more human judges or referees to simultaneously analyze the motion of many athletes that are competing in the sporting event. Due to a limited number of judges or referees, not every illegal contact will be seen and "called." Missed calls can drastically change the outcome of the sporting event and adversely affect spectators' enjoyment and/or satisfaction.

Motion of the human body has been studied with numerous sensors in the context of virtual reality systems. Sensors for virtual reality systems are described in a number of U.S. Patents, including (1) U.S. Patent No. 5,930,741 to Kramer and assigned to Virtual Technologies, Inc.; (2) U.S. Patent No. 5,913,727 to Ahdoot; and (3) U.S. Patent No. 5,563,988 (hereinafter "the '988 patent") to Maes et al. and assigned to Massachusetts Institute of Technology (MIT). The contents of each of those patents is incorporated herein by reference.

Sensors for non-virtual reality environments are described in U.S. Patent No. 5,875,257 to Marrin et al. and assigned to MIT. Ms. Marrin is also the author of several papers that describe using a conductor's jacket with sensors to gather gesture and physiological data on conductors. Two of those papers include: (1) The "Conductor's Jacket": A Wearable Interface for Music and (2) The Conductor's Jacket: A Testbed for Research on Gestural and Affective Expression. The contents of that patent and those papers are incorporated herein by reference. However, those papers and patents do not address the physical interaction of one athlete with another during a real, as opposed to virtual, sporting event.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a monitoring device, system and method for aiding those persons who are officiating at a sporting event (or competition) to determine if illegal contact has, or has not, been made between players.

This object and other advantages are obtained by providing at least one participant with (1) at least one garment fitted with sensors for detecting illegal contact and (2) a transmitter for transmitting the conditions sensed by the sensors.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Figure 1 is an overview of one application of the method and system of the present invention;

Figure 2A is block diagram showing the various components (and their interfaces) of the wearable computer according to a first embodiment of the present invention;

Figure 2B is a block diagram showing a logical grouping of components by function; and

Figure 3 is schematic illustration of exemplary mounting locations for the various components of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to Figure 1, in a soccer game (which is but one possible use of the present invention), plural participants 200A - 200C are outfitted with wearable computers (not shown) which are monitored by a monitoring station 220. Such a monitoring station 220 can any one (or a combination of) (1) a stand-alone computer (Figure 1), (2) a network of computers (not shown), or (3) a portable computer (e.g., a Personal Digital Assistant or a computer integrated with a cellular or other wireless communications link). One factor in choosing which type of monitoring station 220 to select is the amount of processing power needed by the monitoring station 220. If many participants are to be simultaneously monitored, the computing "horsepower" of the monitoring station may need to be distributed between plural computers.

As shown in Figure 2A, one embodiment of a wearable computer includes: at least one garment sensor 101 mounted on a participant's garment(s), a microcontroller unit (MCU) 105, memory (e.g., ROM 112 or RAM 113), a transmitter 109, and a power supply 114. Examples of garment sensors 101 include, but are not limited to, accelerometers, strain gauges, and optical

flex sensors. Accelerometers are appropriate for measuring sudden motion (e.g., a jerk). Optical flex sensors measure an amount of bend. Additional information about such sensors can be found in the '741 patent. As would be appreciated by one of ordinary skill in the art, any type of volatile memory (e.g., DRAM, SRAM) can be used for a working area, and any type of non-volatile memory (e.g., EPROM, EEPROM, Flash memory, and Ferro-electric memory) can be used to permanently or semi-permanently store code and configuration information.

In an embodiment in which plural garment sensors 101 are used, the wearable computer further comprises a multiplexer for multiplexing the outputs of the sensors to the MCU 105. In those embodiments in which the garment sensors output analog signals, an analog-to-digital convertor 103 may also be required if the MCU 105 does not accept analog inputs (either directly or through the I/O interface 104 described below).

Using the program stored in the memory of the wearable computer, the MCU 105 is able to monitor the garment sensors 101 according to the present invention. In one embodiment, the MCU 105 polls each of the garment sensors 101 to determine the status thereof. In an alternate embodiment, the MCU 105 receives an "interrupt" from one of the garment sensors indicating that new information is available from a sensor. As would be appreciated by one of ordinary skill in the art, the MCU 105 may require an external I/O interface for coupling analog or digital outputs of the sensors 101 and 108 to the MCU. However, some embodiments of the MCU 105 will include an integrated I/O interface and will not require a separate, external interface 104.

In a first embodiment of the MCU 105 (and its corresponding code), having received new information from the sensors 101, the MCU 105 controls the communications interface 111 to send data to the monitoring center 220 using a wireless transmitter 109. As would be appreciated

by one of ordinary skill in the art, the wireless transmitter 109 can be based on either radio frequency or light-based transmissions. Such wireless transmitters include, but are not limited to, RF transmitters and IR transmitters. The monitoring station 220 then (1) receives the sensor information using a corresponding wireless receiver (not shown) and (2) analyzes the sensor information locally to determine if any one of a specified set of sensor conditions is met.

In a second embodiment of the MCU 105 (and its corresponding code), having received new information from the sensors 101, the MCU 105 analyzes the sensor information locally to determine if a specified set of sensor conditions is met. If any one of the specified conditions is met, the MCU 105 transmits to the monitoring station 220 that the specified condition has been met.

In some embodiments, a participant's garment is further equipped with a wireless receiver 110 for receiving information from the monitoring station 220, another participant, an official, or a coach. Such received information can be used to ensure that each participant's equipment is working properly. (An indication of the last time that a message was received can be sent back to the monitoring station along with the information from the rest of the sensors.)

Communications received by the wireless receiver 110 are passed to the MCU 105 using the communications interface 111. Moreover, as would be further understood, a single transceiver (not shown) can be used to replace the separate transmitter 109 and receiver 110. Furthermore, plural transceivers can be used if multiple communications are to be carried on simultaneously.

In embodiments in which contact between participants is to be monitored, the garment of each participant is further equipped with an ID receiver 107 (coupled to an ID sensor 108) and an ID transmitter 106 (for transmitting the unique ID corresponding to the garment). One

embodiment of such an ID transmitter 106 is a low power, low range RF transmitter. Thus, the receiver 107 will only receive a strong signal when physical contact is made between participants. In such an embodiment, the physical contact between participants begins a series of sensing operations which would indicate one of the specified sets of conditions. By limiting sensing operations to a period after contact has been made, it is possible to reduce the power consumption of the garment. This prevents or reduces (1) the need to change power sources during play and (2) the number of false detections which were actually caused by the participant himself/herself.

Exemplary sets of conditions are described below to illustrate some of the environments in which the present invention is applicable. In a soccer match, the garment is analyzed for conditions indicative of a participant being held. Since a referee may be on the opposite side from a first participant holding a second participant, the garment will "see" the hold by analyzing the conditions (e.g., accelerations or strains) occurring close in time to the contact between participants. One possible configuration for the garment sensors 101 used on a soccer garment are illustrated in Figure 3. (As would be appreciated by one of ordinary skill in the art, the placement of the garment sensors 101 in Figure 3 is significantly more important than the placement of the remaining elements of that figure). Those garment sensors 101 are further positioned such that if a garment does not detect that two participants touched, then it is a good indication that a referee should not call a penalty, even if a participant appeared to be touched (and is acting or saying that he/she was touched). According to experimental results, it appears that the placement of garment sensors 101 is most effective across the participant's torso.

However, not all sports prohibit all types of contact. American football has "illegal holding" for offensive players as well, but some contact with the defenders is permitted. Thus, as would be appreciated by one of ordinary skill in the art, the system of the present invention must be able to distinguish between innocent and prohibited contact. For example, an offensive player can utilize open hands to block a defender, but cannot pull at the defender's jersey. Likewise, a defender can "bump" an offensive player in the first few yards of a pass play, but that offensive player may not be bumped after the quarterback has thrown the ball. Accordingly, the monitoring station 220 can monitor the offensive receivers' garments for signs of a bump only after the quarterback has thrown the ball, thereby saving power.

Wearable computers integrated into garments can further be used in American football to detect when a ball carriers knee has touched the ground, thereby signaling the end of the play. Similarly, an offensive lineman's jersey can be fitted to determine if he moves prematurely (i.e., before the ball is "snapped"). On the contrary, a defender is allowed to move prior to the "snap," but the defender may not touch the jersey or body of any opposing players. Sensors can pick up each of those motions or contacts.

Although not strictly a "garment," the helmet of an American football player can likewise be fitted with strain gauges to determine if the player's face mask is pulled. Such a strain gauge may further provide an indication of how hard the face mask was pulled to determine the severity of the penalty.

As would be appreciated by one of ordinary skill in the art, baseball players could also be fitted with similar sensors integrated with or attached to baseball garments. Using garment sensors 101, an umpire can more accurately determine if a baseman (e.g., the first baseman)

actually "tags" a runner. Similarly, if a low range, low power transmitter is integrated into the bases, then the system can measure if a player is touched first by a baseman or touches the base first. Similar baseball sensors can be used to determine if a pitcher commits a "balk" or if a batter "breaks his wrists" when trying not to swing at a baseball.

In a Judo training environment, when two trainees spar, the patterns of tugging may be monitored by the coach. The present invention is also applicable to simulation environments (e.g., police studying the moves of a pickpocket where a contact is followed by a particular pattern of movements).

As would be appreciated from the forgoing, the present invention is not limited to the real-time analysis of movement. For example, rather than a coach monitoring Judo movements in real-time, the coach or the sparring partners could play back the movements as part of an analysis of the training or lesson.

In an alternate embodiment of the present invention, the power pack of the wearable computer is augmented with or replaced by "human power." Examples of such power sources are described in (1) Kymissis et al., "Parasitic Power Harvesting in Shoes," Second IEEE International Conference on Wearable Computing, and (2) T. Starner, "Human-powered Wearable Computing," IBM Systems Journal, Vol. 35, Nos. 3&4, 1996, p 618-629. The contents of those articles are incorporated herein by reference.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein. For example, each of the elements of Figure 2A can be integrated into one or more larger circuits

(e.g., application specific integrated circuits (ASICs) or Field Programmable Gate Arrays (FPGAs)).

CLAIMS:

1. A control system for detecting an action performed and experienced by a participant during an observed series of motions in a sporting event, the system
5 comprising:

a sensor mounted on a garment of the participant for detecting a motion condition during the observed series of motions;

- 10 a microcontroller for receiving the motion condition during the observed series of motions, and for analysing the motion condition to determine if the garment has been pulled or tugged;

- a wireless transmitter for transmitting the received motion condition to a
15 monitoring station of an observer of the observed series of motions during the observed series of motions; and

- a contact sensor with an radio frequency (RF) receiver for detecting if two participants contact each other during the observed series of motions, and for detecting
20 strain or flex applied to the garment.

2. The system as claimed in claim 1, wherein the motion condition is analyzed at the monitoring station during the observed series of motions to determine if a specified condition is met.

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3. The system as claimed in claim 1, further comprising:

a non-volatile memory for storing a unique ID; and

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an RF transmitter for transmitting the unique ID between participants during contact.

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4. The system as claimed in claim 1, wherein the sensor comprises an accelerometer.

5. The system as claimed in claim 1, wherein the sensor comprises a strain gauge.

6. The system as claimed in claim 1, wherein the sensor comprises a flex sensor.

7. The system as claimed in claim 1, further comprising a conductive material connecting the sensor and the microcontroller.

8. The system as claimed in claim 7, wherein the conductive material comprises at least one of: wires, conductive thread, and conductive yarn.

9. A control system for detecting, a series of actions performed and experienced by a participant during an observed series of motions in a sporting event, the system comprising:

plural sensors mounted on a garment of the participant for detecting plural motion conditions during the observed series of motions;

a microcontroller for receiving the plural motion conditions during the observed series of motions ; and for analysing the motion condition to determine if the garment has been pulled or tugged;

a wireless transmitter for transmitting the received motion condition to a monitoring station of an observer of the observed series of motions during the observed series of motions; and

a contact sensor with an radio frequency (RF) receiver for detecting if two participants contact each other during the observed series of motions, and for detecting strain or flex applied to the garment.

10. The system as claimed in claim 9, wherein the motion condition is analyzed at the monitoring station during the observed series of motions to determine if a specified condition is met.

11. The system as claimed in claim 9, further comprising

a non-volatile memory for storing a unique ID; and

an RF transmitter for transmitting the unique ID between participants during contact.

12. The system as claimed in claim 9, wherein the sensor comprises an accelerometer.

13. The system as claimed in claim 9, wherein the sensor comprises a strain gauge.

14. The system as claimed in claim 9, wherein the sensor comprises a flex sensor.
15. The system as claimed in claim 9, further comprising a conductive material
5 connecting the sensor and the microcontroller.
16. The system as claimed in claim 15, wherein the conductive material comprises
at least one of: wires, conductive thread, and conductive yarn.