

5 Electronic scoring system, method and armor for use in martial arts

TECHNICAL FIELD

10 The present invention relates to electronic scoring systems, methods and armor for use in the martial arts, and in particular in weaponry-focused martial arts as well as the martial arts or martial-style arts generally.

BACKGROUND

15 The martial arts (e.g. karate, kendo or martial-style arts), including martial-style arts such as kick boxing, Brazilian Jiu Jitsu, fencing and other fighting arts, have a long tradition in many cultures. Martial arts are perhaps popularly recognised as originating from Asia but also have a long history in many other cultures and
20 extend into modern culture today.

The martial arts are systems of codified practices and traditions of training for combat and may involve light- to medium-contact or full-contact sparring. Some forms of martial arts training and competition include the use of specialised
25 weaponry (e.g. the *shinai* [Japanese sword] in kendo). In each case, a scoring system may be used that involves allocating points for striking identified "target" areas on the opponent's body with a specified part of the attacker's body (e.g. hand, foot, elbow or knee) or with a specified part of a weapon. For example, in kendo a point in competition is only awarded when the attack is made to a target
30 area on the opponent's body and when the attack is made with the spirit, *shinai* and body as one. The *shinai* must strike the target soundly, including making contact with the top third of the *shinai*, with the direction of movement of the *shinai* being technically correct.

35 Currently the assessment of martial art combat technique is made visually by judges or through the incapacitation of an opponent. A key constraint in terms of

5 visual judgement is the difficulty of observing attacks with the naked eye – for
example, owing to the speed of the attack it may be difficult to accurately assess
the location and force of the impact from an attack, or whether any real impact
and damage was made (other than by reliance on physical cues such as a knockout
or other incapacitating injury to a competitor). Human error, corruption and bias in
10 refereeing are disadvantages with visual scoring systems. Another disadvantage is
that close observation of attacks by a judge or referee carries the risk of serious
injury or death, particularly when weaponry is involved.

The real risk of injury to competitors, particularly when weaponry is involved, has
15 caused a decline in popularity of many martial arts in which full-contact combat or
sparring is considered too dangerous (and/or unethical). This has led to full contact
weapons-based competitions being restricted or prohibited in a number of
countries. Thus some martial art systems are dying out through the lack of
opportunity to compete in those martial arts safely.

20 Western fencing is an example of a martial-style art involving the use of weaponry
(such as foils, épées, sabres – three kinds of swords used in Olympic fencing).
Scoring involves landing a “hit” in a target area on an opponent. Ways used to
overcome the difficulties of the visual scoring system used in fencing have included
25 using ink on swords so that when an opponent’s jacket is hit, it would stain and the
number of “hits” could be counted. This method had the disadvantage that
competitors could cheat by putting vinegar on their jackets so the ink would not
show, thereby disguising the number of times a competitor had been hit.

30 To overcome the above problem, electronic scoring systems have been introduced.
In fencing, for example, this involves an electrically conductive jacket (lamé) and
mask defining the target (scoring) area and a push-button on the tip of the blade
(or other form of pressure-sensitive tip). The electric weapon (foil, épée or sabre)
in conjunction with the lamé form a single electric circuit. A valid “hit” by the
35 electric weapon onto the lame or mask closes the circuit and causes a light to turn
on. The jacket and mask are connected electronically to a scoring machine so “hits”

- 5 can be registered electronically when the tip of the blade makes contact with the lamé or mask. A hit is registered only when the push button is hit by a force of the specified minimum magnitude and remains fully depressed for the specified duration.
- 10 In fencing with foils and épées only hits made by the tip of the blade count. In fencing with sabres, any contact between any part of the blade and any part of the target counts. Alternative scoring systems involve a normally closed electrical circuit with a break in the circuit opening the circuit and illuminating a light.
- 15 The limitation of this type of electronic scoring system is that it only measures when contact has been made, it does not determine the location on the body of the strike, the strike's direction or the strength of the striking force. This limits its usefulness in relation to other forms of martial arts in which electronically scoring the location of the hit and its force and direction would be useful and also to
- 20 weaponry-based martial arts where it might be preferable in some circumstances to measure the potential "damage" inflicted on an opponent rather than only recording that contact has been made.

Other limitations of electronic scoring systems such as used in fencing include:

- 25 a. the "scoring circuit" (formed by the jacket, mask and electric weapon) is specific to the particular martial art. For example, in foil fencing, the target area (and hence lamé) is restricted to the torso, while in épée fencing the target area includes the entire body, and in sabre fencing the target area is the "saddle line" – from one side of the hip to the other and up, including
- 30 the head but not the hands. The "scoring circuit" is limited to the target area relevant to one art and not another, and hence is unable to register hits outside the target area of one art but within the target area of another art.
- b. the weapon must strike the opponent before a score is registered -
- 35 therefore, the risk of injury to the opponent is real, thereby limiting its

5 usefulness in a wide range of weaponry-based martial arts where the risk of injury caused by a striking weapon is too great.

- c. the ability to score is limited to contact by an electric weapon – therefore, there is limited use in martial arts where scoring involves striking by a body part (e.g. fist, elbow, foot) or non-electric (unmodified, traditional) weaponry.

Yet another disadvantage of the system used in fencing is that the pressure sensor is on the weapon itself. Forms of martial art weaponry are varied and used in a variety of ways – it is of limited use to have a weapon-based sensor since scoring includes measures beyond whether a weapon makes contact with an opponent.

15 For example, in martial arts weapons based fighting, the techniques used are not solely with the weapon. Fists, knees, elbows, feet, shins, shoulders, forehead, fingers etc are also used. Therefore electrifying the weapon or placing sensors over the weapon is not an effective means of scoring a combat technique. Further, a weapon can be used in a variety of ways and so sensors would be required to

20 cover all of the striking areas of the weapon. (Exemplary martial art weaponry includes Guandao, La canne, Baton francais, Shareeravadi/bamboo pole, Naboot, Hanbo, Jō, Tambo, Monk's spade, Sai, Butterfly sword, Vettukathi (sword), Krabi, Epee, Foil, Sabre, Hook sword, , Suntetsu, tiger claws, Shuko/Bear claws, Karambit Tonfa, , Jitte, Tanjo, Otta, Kanabo, Taiaha, Urumi/Chuttuval/wire whip, Chain

25 whip/connected rods, Rope dart, Manriki-gusari, grain flail, , san set sukon 3-PC staff, Kusari-fundo, Tessen/fighting fan,, Siangham/fighting arrow, Throwing knife, etc).

Many martial arts weapons are used in conjunction with very specific forms of armor such as Kali / Escrima Armor made from steel visor and padded neck,

30 shoulder and chest tunic, or Myunjebaegab, a bullet proof armor made of 13 layers of cotton. Armor sets such as Bogu is used in the discipline of kendo, consisting of pants and wire mask, which is quite different to other forms of martial art armor. Likewise, Dō-maru is a Japanese wrap around style suit which is particularly

35 defined by the absence of a solid breastplate or sleeves. Dō-maru armor is wrapped around the body rather than being put on in sections. There are

5 thousands of forms of martial arts covering most regions of the world. Therefore,
there is the need for force sensing and force locating means to be applied to an
armor that can be used in a variety of martial arts.

10 In Taekwondo, a chest plate incorporating a force platform has been used. The
chest plate offers rudimentary protection to the wearer, since it is made from
padded material such as cardboard or leather and therefore would not provide
sufficient protection against hard weaponry. The force platform suffers the further
disadvantage that it only records whether contact has been made, not the
location, direction or magnitude of the contact force.

15 Other systems have been proposed to measure the impact of a weapon as it
strikes. For example, US patent No. 7,278,290 requires the target to be of a solid
durable substance such as steel or titanium. A layer of elasto-luminescent material
composed of zinc sulfide and manganese are embedded over this durable layer.
20 The elasto-luminescent material is designed to emit light or exhibit luminescence
when elastically strained, for example when a projectile strikes the material.

Photosensitive sensors are deployed at strategic locations to allow observation and
recording of the target before, during, and after impact by a projectile. These
25 images capture the target's luminescence at impact and the projectile's impact
location. The images are then transmitted to a traditional image processing system
that can isolate the impact location and correlate the light wave length and
intensity with a known kinetic energy value that was obtained through initial
calibration of the system.

30 The limitations of such a system include:

1. in order to record a hit, a solid and durable impact plate such as a steel or
titanium is required in the target area;
2. analysis of the luminescence data is not dynamic enough for analysis during
35 a martial art challenge;

- 5 3. martial art competitions take place at close range where strikes can be
occluded from view and the duration of luminescence on impact is
transient, and therefore insufficient to overcome the problem of scoring
with the naked eye;
- 10 4. repetitive striking at the same position with the same force may not
produce a reproducible result on a elasto-luminescent surface; and
5. martial art armor comes in a variety of forms and it often is composed of a
material that is traditional such as wood, cloth, tin, steel of particular
shapes and styles. Therefore it is a limitation to have the elasto-
luminescent composite material and adhere it to the underlying material.

15 US patent No. 4,761,005 discloses a means for using a transducer to measure an
impact by a piezoelectric signal. Specifically this patent relates to the field of
evaluating combative performance and its scoring in martial arts. However, the
device described in US patent No. 4,761,005 is limited to being placed on top of or
sandwiched within, a deformable material. Therefore, it is of limited use in impact-
20 protective materials.

 US patent 6,056,674 discloses an apparatus for boxing including a sensor
mechanism in contact with insulated clothing. The apparatus identifies when a
punch having at least a predetermined level of force contacts the clothing. The
25 clothing is insulated to protect the wearer. The insulation includes a plurality of
fluid bags or foam, and is in communication with pressure sensors, which in turn
communicate with a display mechanism. The display mechanism identifies when a
punch contacts the clothing and can detect the force and location of the punch.
Although the apparatus can count the number of punches received over time, it
30 does not measure the duration of each punch (which is required to calculate the
power of each punch) or the direction of force applied (which also assists in
calculating damage value). These latter pieces of information are important for
more accurate scoring in martial arts.

35 Each of the patents mentioned herein is expressly incorporated herein by
reference in its entirety.

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There is a need for an electronic scoring system for use in the martial arts that can be used across a number of martial arts, that can measure the location on the body (e.g. rib cage, jaw, throat) and the direction and magnitude of force applied (e.g. made by a weapon, a body part, or a fall), and that can double as protective armor (particularly in weapon-based martial arts) by absorbing or dissipating the force, thus providing a means for electronic scoring in martial arts without requiring the opponent to receive a damaging strike that inflicts pain, injury or worse.

15 It is an object of the present invention to provide a new or alternative electronic scoring system for use in a variety of martial arts (including traditional styles of martial arts, mixed martial arts, weapons based martial arts, mixed weapons based martial arts or the fighting arts generally) that allows an objective determination of the force, location and effectiveness of a force applied during competition, regardless of an origin of the contact force, e.g. without the need for electric weaponry.

SUMMARY

According to an aspect of the invention there is provided an electronic scoring system for use in various styles of martial arts, including:

- (a) armor to provide impact protection, the armor including a sensing means for detecting force parameter data from one or more forces applied to the armor regardless of an origin of the force, wherein said force parameter data includes data regarding:
- 30 i. magnitude,
- ii. location;
- iii. duration; and
- iv. direction,

5 of one or more forces applied to the armor; and

(b) a scoring machine having:

- i. communication means for receiving the force parameter data from the sensing means;
- ii. tallying means for calculating one or more results using the force
- 10 parameter data; and
- iii. report generating means for generating one or more reports,

wherein the scoring machine is capable of generating output for display on a visual display.

According to another aspect of the invention there is provided an electronic
15 scoring system for use in various styles of martial arts comprising:

(a) armor to provide impact protection, the armor having a sensing means that is an integral part thereof, the sensing means being configured so that the armour acts as a sensor for detecting force parameter data of each contact regardless of an origin of the contact, the sensing means
20 generating a force parameter data signal that is based on one or more sensed contact forces, wherein said force parameter data includes data regarding:

- i. magnitude,
- ii. location;
- 25 iii. duration; and
- iv. direction

of one or more forces applied to the armor; and

(b) a scoring machine having:

- 5
- i. communication means for receiving the force parameter data from the sensing means;
 - ii. tallying means for calculating one or more results using the force parameter data; and
 - iii. output means for displaying one or more results,
- 10 wherein the scoring machine is capable of generating output for display on a visual display.

According to yet another aspect of the invention there is provided an electronic scoring system for use in various styles of martial arts comprising:

- 15
- a. armour to provide impact protection;
 - b. at least one first sensing means that is associated with the armour and is configured to measure and record force parameter data of each force applied to the armour regardless of an origin of the force, the first sensing means generating a force parameter data
- 20 signal that is based on one or more sensed forces;
- c. at least one second sensing means that is associated with armour and is configured to measure and record data relating to a competitor; and
 - d. a scoring machine having:
- 25
- i. communication means for receiving the force parameter data signal from the first sensing means and the data from the second sensing means;

- 5 ii. calculation means for calculating one or more results using
the force parameter data and the data from the second
sensing means; and
iii. output means for displaying one or more results.

10 According to a further aspect of the invention there is provided an electronic
scoring method for use in various styles of martial arts including the steps of:

- (a) detecting force parameter data from one or more forces applied to the
armor that is configured to be worn by a user, wherein the armor provides
impact protection;
- 15 (b) communicating the force parameter data to a scoring machine; and
(c) calculating a result using the force parameter data, wherein the force
parameter data includes data regarding:
- i. magnitude;
- ii. location;
- 20 iii. duration; and
 iv. direction

of one or more forces applied to the armor, regardless of an origin of the force.

25 The invention thus provides an electronic scoring system for use in various styles of
martial arts, and which overcomes the problems of prior art electronic scoring
systems by providing a means for measuring the magnitude, location, duration and
direction of any force applied to the armor (e.g. a strike, blow, throw), without the
need for electric weaponry.

5 **BRIEF DESCRIPTION OF THE DRAWINGS FIGURES**

For a better understanding of the invention and to show how it may be performed, a preferred embodiment will now be described by way of non-limiting example only, by reference to the accompanying diagrams.

10 **Figure 1** is a schematic diagram showing an electronic scoring system and an armor for use in the martial arts according to an embodiment of the invention.

Figure 2 is a flowchart showing the steps involved in recording data during competition, converting data to a score, and displaying the score using the
15 electronic scoring system and armor of Figure 1.

Figure 3 is a schematic diagram showing how the armor of Figure 1 may be segmented so that the location of forces can be recorded by reference to a corresponding segment of the armor – such as plotted against a scoring grid as
20 exemplified in Figure 4.

Figure 4 is an exemplary representation of a scoring grid according to one embodiment. The grid illustrates the strike location (i.e. the location of forces applied to the armor) for a theoretical competitor.

25 **Figure 5** is a schematic diagram showing various components, including sensing means, which are associated with the armor of Figure 1.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

The present invention provides a new or alternative electronic scoring system (see
30 item 10, Figure 1) and method, and an armor for use in martial arts (including traditional styles of martial arts, mixed martial arts, weapons based martial arts, mixed weapons based martial arts or the fighting arts generally).

In a preferred embodiment, the armor is an impact-protecting universal armor, for
35 use in various styles of martial arts. Referring to Figure 1, an exemplary arrangement of the armor is depicted in the style of Kendo armor 20. However, for

5 clarity, the preferred embodiment of the armor (as described in more detail later
in this document) is an "universal" armor suitable for use across a plurality of
martial arts styles and mixed martial arts (including without limitation mixed
weaponry-focused martial arts). Therefore, while the styling of the armor 20 may
vary (e.g. in Figure 1 it is depicted as having the appearance of a Kendo armor), it is
10 unlike other martial arts protective clothing since it provides impact protection for
substantially the whole body, including against damage (e.g. puncture or other
damage) caused by a variety of martial arts weapons in full contact martial arts
combat where substantially all body parts are legitimate targets. This is in contrast,
say, to Kendo where the legs and back are off limits.

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The armor 20:

- (a) has access to force sensing means, such as force sensors on or in the armor;
- (b) provides impact protection, including puncture and tear resistant
properties to protect the wearer against injury caused by impact regardless
20 of the origin of the force (e.g. a strike, a throw or other force applied to a
competitor, including forces from the competitor falling onto or against a
contact surface such as the ground or a retaining wall, fence or cage around
the fighting arena), puncture (e.g. caused by a weapon including without
limitation an unmodified, authentic martial arts weapon) or shear force,
25 and/or the impact of a weapon, body part or any other object (e.g. the
ground) striking the competitor); and
- (c) is capable of communicating with a scoring machine 30 (such as a computer
or other processing device), so that force parameter data (e.g. location,
magnitude, duration and direction of force applied) of any force applied to
30 the armor (i.e. regardless of an origin of the force) can be electronically
recorded, measured and/or extrapolated (including without limitation in
real time or near real time) by the scoring machine.

In a preferred embodiment, the electronic scoring system includes:

- 35 (a) universal armor 20 having access to force-sensing means for detecting
and measuring force parameter data;

- 5 (b) a scoring machine (having processing capacity) 30 including:
- i. communication means 40 for communicating with the armor so that force parameter data from the armor can be received, recorded and tallied by the scoring machine;
 - 10 ii. tallying means (not shown) for tallying force parameter data, calculating one or more scores (e.g. individual competitor scores, overall competition scores, score break-downs);
 - 15 iii. report generating means for generating competition reports (including one or more of overall competition score reports, individual competitor scores and score break-down reports, individual competitor strike data reports, competitor analysis reports); and
 - 20 iv. a visual display 50 for displaying data output (including competition reports) from the scoring machine, such as force parameter data. In some embodiments, the visual display is also capable of displaying one or more results such as one or more competitor scores, or other output from the scoring machine, including video imagery of competition and computer generated imagery (CGI).

Figure 2 illustrates the flow of information from the armor to the scoring machine in a preferred embodiment 90. The preferred embodiment of the electronic scoring method includes the steps of:

- 25 (a) detecting force parameter data from one or more forces applied to armor worn by a competitor and regardless of the origin of such forces (e.g. no corresponding part or activator is required for the sensing means to detect force parameter data) (step 100);
- 30 (b) communicating the force parameter data to a scoring machine (step 110);
- (c) calculating a result using the force parameter data (step 120). In one arrangement, the result is a score including one or more of the following:
- 35 i. one or more point(s) accumulation;
 - ii. one or more point(s) deduction.

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As described herein, the electronic scoring method can include the step of visually displaying data and/or scores for each competitor on a visual display or the like (step 130).

- 10 An example of a scoring machine is a computer, including a computer system or network (including a LAN, WAN, the internet or cloud) or any other device (e.g. embedded hardware) with processing capacity and the ability to send data to a visual display (including without limitation in real time or near real time). The scoring machine is enabled to communicate with each competitor. In its minimum
- 15 configuration, the scoring system enables force sensor data to be communicated from each competitor to the scoring machine. The scoring machine utilises a scoring software application to perform the electronic scoring method, including collating, processing, analysing and reporting force parameter data and calculating one or more results such as scores, and is capable of generating output for display
- 20 on a visual display. The scoring software application can be housed on a computer, server, or be network-, internet- or cloud-enabled.

The scoring system typically (but not necessarily) further includes audio means, to enable audio data (e.g. voice) to be received (e.g. from the scoring machine or

25 from an external connected source) by one or more speakers such that it can be heard by one or more of the competitors, a coach or team leader, an audience (whether located locally at the fighting arena or located and viewing the competition remotely).

- 30 In other embodiments, the scoring system further includes one or more of the following:

(a) position-sensing means to allow delivery of location-based services such as locating and tracking the position of individual competitors and delivering position data to the scoring machine, for competition and game play, and

35 later analysis for review and training purposes;

5 (b) security means for securing communications from the armor so that data
detection by various sensors (e.g. the force sensors) and communication to
the scoring machine is secure (e.g. protected from tampering by third
parties);

(c) security means for securing communications (including the viewing of
10 competition and associated CGI, and accessing associated audio data – e.g.
commentary, coaching and competitor communications, announcements,
music, scripting). This enables subscription-based access to the
competition and competition data;

(d) superslow motion video replay means (e.g. recording at 100 frames per
15 second slowed to 1 frame per second) enabled to be viewed on the visual
display; and

(e) motion-sensing means to enable motion capture – e.g. the visualisation and
recording of movement data, the movement data reflecting movement of:

- i. competitors;
- 20 ii. a force-applying member, including:
 - A. an object used to apply a force to a competitor such
as a weapon (or part thereof), including staffs, swords,
clubs, shields, projectile weapons (e.g. arrows, crossbow
bolts, paintballs), fencing weapons or any other weapon or
25 object suitable for use in the martial arts or fighting arts;
 - B. a contact surface used to apply a force to a
competitor (e.g. the ground or a wall),

the motion-sensing means also being enabled to function as position-
sensing means to record position data, in which case the motion-sensing
30 means may be one and the same as the position-sensing means.

Communication means

In its simplest arrangement, the scoring system includes unidirectional
communication means 40, to enable communication from the armor 20 so that
35 force detected by the force sensors in or on the armor is sent to the scoring
machine 30 (as outlined in the preceding paragraph).

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In another arrangement, the communication means 40 are multidirectional. In this arrangement, the scoring system allows data from the scoring machine to be communicated back to the competitor (e.g. cumulative score, or force parameter data relating to each strike, blow, throw, fall, etc, or voice data from a coach).

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The communication means is uni-channel or multichannel, depending on the preferred arrangement. Multichannel communications enable simultaneous communications to be sent and/or received simultaneously.

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For example, in one arrangement, the armor includes headphones in or on a helmet portion of the armor so that the competitor can receive instructions from a coach on one channel. The competitor can communicate back to the coach via a microphone located in, on or near the helmet portion of the armor. This communication is conveyed on a second channel. If there are multiple competitors

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involved in competition (say, in team competition), additional channels are included so that teams of competitors on the fighting arena can communicate among themselves.

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In one embodiment, the communications are carried on secure channels so they are received (e.g. viewed or heard) in a secure environment. For example, a viewing audience can be provided access to, say, coach-competitor communications on a user-pays basis. A coach or competitor can select a different channel for private communications from which the paying audience is excluded access.

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The secure communication means allows subscription-based access on a user pays basis, including options for selectively receiving one or more channels of data (e.g. for a fee per channel or fee per view basis, or a combination thereof).

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In another embodiment, the system further comprises a CGI means (e.g. software) for visually representing force parameter data, including multidimensional CGI

5 rendering of competition, including any one or more of the elements of
competition such as competitors, weaponry, the fighting arena, the referee, the
audience, and/or simulation or re-creation of strikes, blows, throws, falls to visually
depict the force and location of impact and a CGI representation of the "damage
value" of such attacks on competitors on the visual display.

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The CGI means may be integral with the scoring machine 30 or a separate means
that communicates with the scoring machine so that CGI rendering of one or more
visual representations of competition (the visual representations being based on
force parameter data and/or movement data) can be seen on the visual display 50.

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Armor

The armor is "intelligent" by virtue of the fact that, in its simplest configuration, it
possesses force-sensing properties (described later), such as access to force-
20 sensing means, for detecting force applied to the armor. In some embodiments, it
also possesses motion-sensing properties, in-built electrical circuitry and other
components (also described later). The force-sensing means and motion-sensing
means may be one and the same. For example, accelerometers, which are used to
measure acceleration (e.g. by measuring displacement of a mass), can be used to
25 indirectly measure a force applied to the accelerometer. Similarly, the motion-
sensing means and position-sensing means may (but not necessarily) be one and
the same.

The armor is also "universal" in the sense that it is suitable for use across a
30 plurality of martial arts styles and mixed martial arts. The armor is not limited by
any current rules-based system, e.g. for Kendo, in which strikes to the back and
legs or using the butt of the shinai (kendo sword) are not permitted.

The armor in one embodiment provides protection to one or more of areas of the
35 body, including the front, sides and back of the torso, the front, sides, top and back
of the head and neck, collar bone, shoulders and/or around the limbs. In the

5 simplest arrangement, the armor covers the head and neck. However, in other
arrangements, the armor covers the head, neck and torso, or the entire body. As
substantially full body protection is essential in weaponry-focused martial arts full
contact competition (using unmodified, authentic martial arts weapons, including
sharp weapons), the preferred embodiment includes armor that covers
10 substantially the whole body, including the whole of the head, the neck and torso
and around the limbs.

In the preferred embodiment, the armor 20 is made from an impact-protection
material (described in further detail below) that acts to protect a competitor (the
15 wearer of the material) from injury by absorbing or spreading the impact forces
and preventing penetration or deformation by weaponry. In its simplest
configuration, the impact-protection material is a simple steel, carbon fibre or
Kevlar. In other embodiments, the impact-protection material is an intelligent
material or coating with force-absorbing or force-dissipating properties.

20 The protective armor 20 of the preferred embodiment also has force sensing
properties – hence making the armor “intelligent”. This enables the armor to act as
a force sensor, recording and measuring contact forces and the specific location of
contact or contacts, and sending this data to a computerised scoring software
25 application, hardware, system or network (“scoring machine”) in real time.

In other embodiments, the armor includes one or more of the following additional
further features:

- 30 (a) in-built electronic circuitry for driving components of the armor that
require power (e.g. sensing means, a light or light-emitting means, a
camera as described below) – this can be provided by nanomaterials such
as carbon or silicone nanotubes (e.g. buckytubes) or nanospheres (e.g.
buckyballs) or other similarly electroconductive nanomaterial;
- 35 (b) one or more headphones in or on a helmet segment of the armor to enable
the competitor (wearer) to receive and hear audio data;

- 5 (c) a microphone in, on or near the helmet segment of the armor, to enable the audio data (e.g. speech) to be sent from the competitor (wearer) to, say, the scoring machine, or coach, audience, team members, or an opponent;
- 10 (d) motion-sensing means, including accelerometer(s), light-based motion-capture sensors, or heat-emitting and heat-sensing means, or any other suitable motion capture technology including optical and non-optical motion capture systems, to enable detection (including measurement) of the magnitude, speed (distance / time), direction and path of movement of:
- 15 i. a competitor (e.g. when thrown);
- ii. a force-applying member (e.g. a weapon or other object used to apply a force during competition); or
- 20 iii. any other object associated with the competitor (e.g. a marker or sensor placed on the competitor, on the armour or on a force-applying member being held or used by the competitor).

In some arrangements, the motion-sensing means and force-sensing means are integrated. In yet other arrangements, motion and/or force sensing means (e.g. accelerometers) are used in combination with position-sensing means (e.g. location-based, or local- or global-positioning system technologies, or locating technologies) to measure force(s) based on displacement of a competitor or part thereof;

- 25 (e) location-based services and locating technologies to enable positioning / locating of individual competitors to be recorded – this has particular application for team competition (described later) and for subsequent analysis of combat for training purposes;
- 30 (f) one or more cameras in or on the armor (for example, on the helmet portion) to record different viewing perspectives, the data being sent from the camera(s) to, say, the scoring machine visual display so that an audience can view competition from, say, the view from the competitor's eyes, and / or the view from the back of the competitor's head (a 'rear
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5 view'). Cameras also provide optical input for motion capture, whether through motion-sensing means / position-sensing means;

(g) one or more response simulation means (item 240 in Figure 5) positioned on or in the armor, the response simulation means simulating at least part of the effect on a competitor of being struck by a force of the calculated
10 damage value.

In one arrangement, the response simulation means is a light-emitting means on or embedded within the interior surface of the helmet, close to the competitor's eyes. The light-emitting means is triggered to flash and /or
15 change colour (activated) when the intelligent armor detects one or more forces (or accumulation of forces) of a particular threshold "damage value", where the damage value is calculated based on a combination of force parameter data, including two or more of magnitude, location, duration and direction of a force applied to the armor. When positioned on or in the
20 interior surface of the helmet, the response simulation means 240 simulates the visual effects of being stunned in competition, e.g. temporarily distracting or blocking the recipient competitor's vision, a classic 'set up' enabling a knock out strike to then be delivered while that competitor is "stunned". Although a competitor wearing intelligent armor will not be knocked out, the electronic scoring method takes into account
25 successive strikes so that a flash-triggering strike (stun force) delivered near simultaneously or shortly before a force that would be sufficient to knock out the other competitor may result in a points score advantage to the competitor delivering the theoretical knock-out strike or a points score
30 deduction from the competitor receiving the strike. In yet another arrangement the light-emitting means within the helmet further includes a colour code system, in which different "damage value" is represented by different coloured light. For example, green light means that damage value of a particular threshold value has been sustained, while amber means a
35 greater damage value than green. Red represents even greater damage value still, such that the competitor (had he or she been unprotected by the

5 armor) would theoretically have been rendered sufficiently incapacitated to
be "knocked out" or otherwise unable to compete.

A similar principle can be applied in an alternative arrangement of the
response simulation means in which the armor includes a shock-emitting
10 means that is configured to activate or trigger (i.e. deliver an electric shock)
when a force of a particular threshold value is applied to the armor. The
electric shock is not sufficient to injure the competitor but is applied on the
same side of the body as the triggering force is applied and configured to
elicit a reaction (e.g. flinching) from the competitor. This is so that when a
15 competitor wearing the armor receives a blow, there is at least some visual
simulation of a reaction from the competitor (who is in fact shielded from
the blow by the armor). This enhances the visual experience of watching
competition (because some physical reaction to a strike is elicited from a
competitor wearing armor) and also has advantages in training where a
20 competitor needs to understand the damage value of forces applied and
received.

Sensing means

In the preferred embodiment, the armor 20 has access to sensing means 200
25 (Figure 5) such as force sensors to enable force parameter data (e.g. location,
strength, duration and direction) of forces applied to the armor, or any part of it,
to be sensed and communicated to a scoring machine (e.g. a computer). The force
sensing properties of the armor are provided by a sensing means embedded into,
or layered upon, or lined within, the armor to ascertain the force and the position
30 of a strike made to the armor. In another embodiment, the sensing means 200 is
embedded in a skin worn over traditional armor.

In one arrangement of the preferred embodiment, the sensing means 200 is a
plurality of force sensors (e.g. a force sensing material, a force conducting polymer,
35 a shape memory alloy, or other force sensors, including accelerometers for indirect
measurement of force) embedded in or on the armor, connected in arrays. The

5 advantage of using accelerometers to indirectly measure force is that the same
sensing means can also be used to measure (whether directly or indirectly) other
force parameter data (location, duration and direction of force(s) applied). Having
integrated sensing means (i.e. sensing means that can measure more than one
parameter) assists in making the armor more comfortable to wear. Further, micro
10 electro-mechanical systems (MEMS)-based accelerometers can be integrated or
used with other MEMS-based accelerometers so that collectively they are sensitive
in multiple planes (e.g. can detect forces and movement in multiple planes).

In some arrangements, motion and/or force sensing means (e.g. accelerometers)
15 are used in combination with position-sensing means (e.g. location-based, local- or
global-positioning system-type technologies or motion capture positioning
technologies) to measure force parameter data based on displacement of a
competitor or part thereof.

20 In one arrangement of the preferred embodiment, the sensing means 200 is a
plurality of force sensors (e.g. a force sensing material, a force conducting polymer,
a shape memory alloy, or other force sensors) embedded in or on the armor,
connected in arrays. Each array is connected to a communication device, forming a
module. There may be a plurality of modules weaved through a containing fabric
25 such as armor-covering material. The sensing means (sensors, array and/or
modules) communicates force parameter data to the scoring machine.

In other embodiments, the sensing means further include motion-sensing and/or
position-sensing means. These are described later in this document.

30

The sensing means 200 further includes a switching mechanism 210, enabling the
arrays and/or modules to be switched on either directly or indirectly when the
force sensors detect an impacting force. The advantage of this dynamic switching is
that not all sensors, arrays and/or modules need to be activated at all times.
35 Consequently, the frequency of monitoring can be increased by measuring only

5 from active sensors/arrays/modules rather than monitoring all
sensors/arrays/modules at all times.

An array, matrix or plurality of sensing means 200 is important because martial arts
challenges are performed at extreme speeds and in flurries of action. Traditional
10 scoring systems are often subjective and at best, an estimate only. A plurality of
sensors (e.g. force sensors) enables detection of forces applied in quick succession
(e.g. strikes) and allows recording of simultaneous or near-simultaneous forces
that are difficult to detect visually. It also enables forces from throws and falls to
be recorded and taken into account in competitors' scores. The scoring system
15 may include the dynamic scanning of the array using parallel control circuits in a
modular fashion.

The scoring machine (e.g. computer or other processing device) collects data from
a plurality of sensors 200. The sensors are arranged in arrays, the arrays are further
20 arranged in modules, and each module is capable of connecting to one or more
other modules.

The signal from an array of sensors is multiplexed – that is, converged into an
individual signal over a shared medium (e.g. communication means to the scoring
25 machine). When the multiplexed signal reaches the scoring machine it will be de-
multiplexed back into multiple discrete signals from discrete sensors. This
improves the sampling rate and resolution of the signal from the sensors to be
optimised.

30 Any suitable sensing means may be used. Depending on the individual properties
of the sensing means used, a piezoresistive or piezoelectric effect may convert the
mechanical stress applied to the sensing means to:

- (a) a change in electrical resistance; or
 - (b) a change in electrical charge or voltage (measured as an electrical signal),
- 35 respectively.

5 Piezoresistive, piezoelectric and/or capacitive components of the sensing means are able to be used to convert the mechanical impact into an electrical signal that can be viewed on a visual display of a scoring machine (e.g. a computer or other device with processing capability). Additionally or in the alternative, the electrical signal drives an audible sound and/or visible light.

10

There are many forces that are experienced in combat such as shear forces and flexural forces, which are critical forces in determining the outcome in combat, and therefore the elasticity in all dimensions must be converted to an electrical signal. Therefore, the measurement of force, pressure, and acceleration at many locations on the armor is enabled using:

15

- (a) force sensors include piezoelectric sensors or other pressure sensors – for example piezoresistive force sensors (made by a variety of companies), which are flexible, thin (typically less than the 0.2 mm) and able to sense pressures in the range of 0.1 pounds per square inch (PSI) to 2000 PSI, including piezoresistors fabricated from a wide variety of piezoresistive materials such as silicon;
- (b) accelerometers (made by a variety of companies), including piezoelectric, piezoresistive or capacitive accelerometers, and micro electro-mechanical systems (MEMS)-based accelerometers, which can be used to indirectly measure forces applied (among other force parameter data);
- (c) tactile sensors in the form of conductive cloth-based conductive sensory arrays consisting of a plurality of parallel electrodes threaded through material that can be stretched in multiple directions so as to provide information about pressure distribution along a surface; or
- (d) a shape memory alloy (SMA) whose resistance changes with deflection such that an electrical signal is generated. SMAs are metal alloys that "remember" their shape, and can be returned to that shape after being deformed. As the shape alloy deforms, the impedance of the SMA alters and therefore a measurement of deformation (as a function of force) is able to be monitored at its specific location.

35

5 SMAs provide a means to measure a variety of forces including compression, shear and flexural forces.

In the preferred embodiment, the sensing means (e.g. force sensors) send data (e.g. force parameter data) to the electronic scoring system and enable real-time
10 visualisation of force parameters. The data may take the form of raw data or be graphically displayed in the form of a pressure plot displayed on the visual display. The visual display of a scoring machine such as a computer receives force parameter data from the force sensors and displays the data visually in real time on the pressure plot.

15 In an alternative embodiment, the visual display also shows a CGI rendering of the anatomy of the competitor, illustrating where the force was applied. For example, a rendering of the competitor shows where a strike occurred (e.g. an impression of a staff, weapon or other object such as a baseball bat striking the jaw),
20 superimposed by a multidimensional representation of the force and power of the strike. The "damage value" of the strike is also able to be represented as points for the competitor delivering the strike, one or more points deduction for the competitor receiving the strike or a combination. In one embodiment damage value is further represented as a visual rendering of the strike, say, such as an
25 artistic impression of a staff or baseball bat striking a jaw with a corresponding pressure plot showing the relative distribution of forces across the recipient's jaw. Damage value could be further represented as a visual rendering of the strike, again say as an artistic impression, but recalibrated to simulate an edged weapon strike (e.g. virtually replacing the staff with a sword or spear).

30 The sensing means (e.g. force sensors) are capable of being linked by tuning means 230. The tuning means 230 can take the form of one or more hardwired sensor-biasing circuits or a software-enabled means. This tuning means 230 defines the force to voltage relationship for each sensor so that the sensitivity of sensing
35 means (e.g. force sensors) is uniform across one or more arrays. This also provides

- 5 a means of adjusting the signal (including buffering, correcting and/or amplifying the signal) so communication links from different modules can be fully interpreted.

Impact-protection property of the armor

- The armor has impact-protection properties, including protection against injury
10 caused by impact (e.g. a strike), puncture (e.g. caused by an unmodified, authentic real combat martial arts weapon) or shear force. The impact-protection properties of the armor may be provided by an impact-protection material used to make the armor, an impact-protection coating, or lining, or a combination thereof. Any suitable impact-protection material (e.g. steel, carbon fibre or Kevlar) can be used
15 for the armor.

In another embodiment, the armor can provide protection against full contact real combat martial arts weapons including a sharp weapon (e.g. an edged weapon) or weapons.

20

For example, the armor can be made of an impact-protection material or suitable multifunctional electro-active material with sensing properties, including any of the following individually or in combination:

- (a) a shear-thickening or dilatant material or polymer that transforms from a
25 flexible material under normal conditions to a rigid material in response to a shearing force or impact;
- (b) a magnetorheological material that transforms from a flexible armor to an extremely stiff material when a magnetic field is applied or interrupted;
- (c) a shape memory alloy embedded in the armor;
- 30 (d) a ballistic material such as spun ultra high molecular weight polyethylene bonded into sheets and layered at angles to produce a composite material with puncture resistant properties, suitably coated to achieve force sensing properties (e.g. with a conducting substance such as a conducting polymer); and/or
- 35 (e) a nanomaterial or coating. This allows electronic circuitry to be interwoven into the fabric to enable wireless communication or to allow power to be

- 5 delivered to drive other components (e.g. a camera or light-emitting means);
- (f) a power source such as a rechargeable battery in a thin film and flexible form – this includes, for example, flexible film batteries having an integrated circuit card, housing memory storage and microprocessing capabilities.
- 10

Universal nature of the armor

In a preferred embodiment, the armor is a universal armor for use in almost any martial art (e.g. worn over the traditional uniform). This enables measurement of the magnitude and location of forces in a variety of martial arts styles, using various weapons or no weapons, all while still protecting competitors.

15

By providing a universal armor, the preferred embodiment is useful for “cage fighting” (mixed martial arts competition) as well as various forms of martial arts, not confined to a specific form of martial art.

20

In an alternative embodiment, the armor can take the form of a traditional uniform used in a particular martial art. Hence, the armor may be a traditional uniform made from an intelligent textile with suitable properties or a traditional uniform coated with a suitable material to give it the required properties such as impact-protection, force-sensing, electroconductive and so on.

25

Force parameter data

In any arrangement, the armor is divided into segments (see item 60, Figure 3) so that different segments or portions of the armor correspond to different parts of the body (see Figure 3). This enables the magnitude, direction, duration and location of force applied to the armor (force parameter data) to be recorded by reference to pre-determined anatomical regions or mapped against grid co-ordinates on a scoring grid (see item 70, Figure 3) corresponding to armor segments and that can be displayed on the scoring machine visual display 50.

30

35

5 Unlike prior art electronic scoring as used in fencing, the preferred embodiment records the specific location, magnitude, direction and duration of combative forces applied using any means (e.g. traditional weaponry or a body part). This is important to assess the "damage value" of a strike. For example, the strike force can be light but targeted so that it blocks blood or air supply (e.g. by collapsing the
10 oesophagus) and therefore is crippling to an opponent. Conversely, a strike may be delivered with extreme power, also inflicting significant damage to an opponent (e.g. breaking the neck). Further the angle (direction) at which a blow is received by a particular part of the body (location) may affect the amount of 'damage' inflicted. For example, the specific magnitude of force applied to the, say, jaw at a
15 45° angle sideways or upwards will deliver a greater degree of damage compared with the same force applied squarely onto the jaw. The force parameter data contained in a pressure profile of a force so applied enables extrapolation of the force direction vector, which is significant for calculating a score or "damage value" of a particular attack (see discussion later in this section).

20

Winning in martial arts combat relies on, amongst other things, the ability to make contact with the opponent's head or body with sufficient force and technique to cause damage or injury without sustaining injury yourself. It is an advantage over the prior art to be able to record with specificity the location and direction of
25 strikes and the differentiation of force applied not only from use of body parts to attack (such as fists, knees and elbows) but also from weaponry; and for the armor to be able to withstand the impacts from multiple and repeated weapon strikes and to retain the ability to record the data from these strikes. This is because in real martial arts combat, avoiding strikes, preparing for a counterstrike and striking
30 with sufficient force and technique are all part of competition, not only landing a strike within a target area.

Scoring depends on the efficiency with which a competitor can deliver a blow, as measured by the total duration of the impact and by the force delivered such that
35 force divided by time gives the measurement of power. Critical also is the location of the impact and the angle (direction) of the attack, and other qualitative

5 indicators such as glancing blows versus direct hits. In martial arts, skills have been measured in an algorithmic manner taking into account force, space (distance from opponent and impact area – e.g. this distance has been measured among Taekwondo competitors and found to lead to significant differences in kicking impact generated by non-expert competitors) and time. Electronic scoring systems as used in fencing or other martial arts electronic scoring systems are unable to take into account these additional factors.

Electronic scoring system and method

Force parameter data recorded by force-sensing means such as force sensors in or on the armor are received by the scoring machine such as a computer, which calculates one or more results, such as scores plotted against a scoring grid 70 for each individual competitor (see Figure 4), thereby providing useful visual means for tracking the performance of individual competitors, including individual strengths and weaknesses in competition (e.g. relative weakness in left upper thoracic strikes). The system also records who hit first and what happened (additionally to how hard).

The scoring machine in another arrangement can also calculate one or more results in the form of the “damage value” of individual forces (e.g. strikes, throws, falls). Damage value can be “raw” or calibrated according to the physical attributes of a force-applying member. The force-applying member can be one or more of:

- (a) an individual competitor;
- (b) a weapon;
- (c) a contact surface (e.g. the ground, a wall, a fence);
- 30 (d) any other object used to effect a strike.

For example, the physical attributes of an individual competitor can be used to calibrate damage value in the following way. A featherweight competitor competing against a heavyweight competitor will suffer greater “damage value” for a strike of the same force made by the same weapon. This can be used to calibrate the lightweight competitor’s scoring so that greater damage value (e.g.

- 5 one or more points deduction), will occur for the same force. Conversely, it can be used to weight a strike so that the same strike force applied to the heavyweight competitor will have greater "damage value" than if applied to the lightweight competitor (a form of "handicapping").
- 10 Alternatively calibration can interpret the result of a strike as if it had it been effected with a sharp weapon (e.g. a sword or spear) versus a staff or baseball bat, and render the result as an artist's impression using CGI.
- 15 The "damage value" of a force applied (e.g. a strike or a throw) is also able to be converted into a scoring advantage or disadvantage – for example, one or more points for the competitor delivering the strike, or one or more points deduction for the competitor receiving the strike, or a combination thereof. In one embodiment damage value is further represented as a visual rendering of the strike, say, such as an artistic impression of a fist striking a jaw with a corresponding pressure plot
- 20 showing the relative distribution of forces across the recipient's jaw. Alternatively, damage value may be represented as a visual rendering or simulation of the damage that would have occurred (e.g. jaw broken) had the armor not been present.
- 25 The scoring machine 30 receives force parameter data in real time or near real time from the armor 20, which is electronically connected (e.g. by wireless communications means) to the scoring machine 30. Force parameters include, for example, the location and magnitude of the force applied, and the power with which the force is applied ($\text{power} = \text{force}/\text{time}$) for all forces applied to the armor
- 30 of a competitor. This is converted by the scoring machine into a result, such as a point score for the competitor inflicting the strike or a point deduction for the competitor receiving the strike. This further allows a result such as the "damage value" of a combat strike to be calculated (based on an algorithm that takes into account force, power, location of a strike and other specified parameters) and also
- 35 to be displayed to an audience along with actual and accumulated scoring. The algorithm may be enabled by software and/or hardware devices.

5

The electronic scoring system includes communication means 220 that are capable of receiving and recording force parameter data from various parts of the armor and relaying the data to the scoring machine. The communication means 220 can include any suitable form of communication, whether wired or wireless. The
10 communication means 220 may involve electronically conductive armor or other means.

The advantage over prior art electronic scoring systems as used in fencing is that strikes made using unmodified weaponry can be recorded and measured, as can
15 strikes made by any body part. By contrast, prior art electronic scoring systems as used in fencing can only record a score when an electric weapon makes contact with electronically conductive protective clothing. Thus a strike made by a body part or by a traditional (non-electric) weapon would not trigger the scoring system to score.

20

Another advantage over the prior art is that the specific location and force (and/or power) of the strike can be recorded. By contrast, prior art electronic scoring systems as used in fencing are simply triggered on (or remain off if the trigger does not exceed a threshold value) to indicate that contact anywhere in the target area
25 was made.

The communication means acts as a transmitter to transmit, say, a pressure signal from force sensors to a receiving device (e.g. a computer that functions as a scoring machine). Similarly, data from other sensing means in different
30 embodiments (e.g. motion-sensing means, heat-sensing means) are transmitted via the communication means to the scoring machine.

In the preferred embodiment, the scoring machine is connected to or contains a processing means to interpret the data signal(s) and calculate a score (or other
35 information) according to a scoring regime or other specified algorithm. In other embodiments, the system also includes CGI means capable of receiving data from

- 5 the scoring machine so that competition data can be referenced, analysed and applied by the CGI means.

The means of transmission between the transmitter and receiver is via wireless communications such as radio-frequency communication or other communication
10 such as infrared, Bluetooth, or near-field communication or any other suitable communication protocol.

The sensors are attached to an interface device to enable the input data (sensor signals) from the armor to be interpreted by the scoring machine (receiving
15 device). The interface has the sensitivity to dynamically and accurately record combat strikes in real time. This enables the scoring machine to take in sensor data, apply it to a scoring regimen, calculate a score and display it.

CGI means

- 20 The "scoring machine" has processing capacity. In one embodiment, it includes capacity for processing of computer graphics, including video. In one arrangement, combat can be viewed in real time or near real time, with strike data overlays or other display of strike data, action replay and computer generated graphic visualisation of strike "damage" indicating where a competitor has been hit and
25 the value of damage to the competitor from each hit, or cumulatively. The CGI means (e.g. software) may additionally include glyphs to enable scene display, combat targets and other visual display elements, for combat replay, modelling or game play.
- 30 In one embodiment, the scoring system includes CGI means (e.g. software) for graphically displaying force parameter data and for multidimensional (e.g. 2D, 3D, 4D) rendering of computer generated imagery relating to competition. This is useful for real and simulated competition, and for combinations of real and simulated competition. In this way, the system enhances the viewer experience
35 when watching competition through visual display of, for example, the simulated magnitude or "damage value" of a strike if the competitor had not been wearing

5 the armor. This can occur in any time frame – for example, in real time, near real time or as a projection into the future, or during an action replay. It may appear as a graphic overlay over video recordings of a competitor or as a CGI rendering of a competitor.

10 For example, consider competition between two competitors in which a first competitor is struck by a second with sufficient force to knock out the first competitor. The first competitor is wearing armor, so is in fact not knocked out. The scoring system registers, however, that the “knockout” strike was made to the temple, with a force of, say 1200 pounds per square inch (PSI). In unprotected
15 competition, the first competitor would be taken out of competition. Thus the scoring system provides a visual simulation of the damage value of a force applied, based on the force parameter data (magnitude, location, duration and direction [angle]) of the force applied. The visual simulation includes an anatomical representation of a competitor’s body (without armor) and a theoretical effect of
20 the force applied upon the competitor’s body. The theoretical effects that may be simulated include effects such as displacement of a body part in a direction of the force applied (e.g. the head thrown backwards by a blow to the jaw or, say a broken jaw from an angled blow to the jaw bone). The latter effect may involve CGI rendering of the skull superimposed on the face of a competitor, with the jaw bone
25 broken at the location where the jaw was struck.

On a visual display connected directly or indirectly to the scoring machine, the visual representation of the first competitor shows the competitor (e.g. in a non-armored state) taking the “knock out” strike from say a staff, CGI of the
30 competitor’s head shows the location of the strike, an artistic rendering of the staff making an “impression” on the temple at the point of strike and a corresponding graphical representation of the various forces over time and/or over distance (e.g. along the skull), and the effect of the strike (e.g. the head is thrown back and the competitor falls).

35

5 Similarly the scoring machine can interpret the result of a strike as if it had it been
effected with a sharp weapon (e.g. a sword or spear) not the specific weapon
actually used, and render the result as an artist's impression using CGI. It can also
calibrate the damage value based on a physical attribute of a competitor and/or an
10 object used to apply a contact force (i.e. the force-applying member, such as a
weapon). For example, using the CGI means a simulation of the damage can be
provided, so that an audience or viewer can see a representation of competitors
(e.g. in a non-armored state) and the degree of damage that would have been
sustained had, say, an edged weapon been used rather than a non-edged weapon,
based on the same force data but recalibrated by the scoring machine (e.g.
15 computer) for a different entertainment experience. Multiple strikes or forces,
including simultaneous strikes of forces, can be recorded and viewed
simultaneously or selectively viewed on the visual display.

The CGI means thereby enables the scoring system to enhance the viewer
20 experience, including in interactive ways and for training and/or entertainment
(e.g. gaming) purposes. The CGI means can be an integrated part of the scoring
system or be connected to it through any suitable communication means and using
any suitable communication protocol.

25 **Position-sensing means**

Certain configurations of martial artists in a team in the fighting arena will have
advantageous positioning, even though the team may not have superior numbers
or better individual competitors. Therefore, tactical positioning (e.g. as used in
chess or military combat) detected through location or position-sensing means can
30 be relayed to and perceived by an audience (or a coach) using location-based
services (to identify the location of a competitor or object).

The scoring system includes position-sensing means to allow delivery of location-
based services such as the tracking of competitor position within the fighting arena
35 (both the physical arena and the corresponding CGI-rendering of the arena). The

5 position-sensing means detects and records position data, including data regarding one or more of the following:

- (a) motion capture data (e.g. through marker and markerless systems);
- (b) locating data (e.g. through localisation through tracking technologies);
- (c) positioning data (e.g. through local- or global-positioning systems).

10

Real-time locating systems are able to dynamically monitor and record positioning such that relative positioning of teams and competitors can be recorded and contribute towards scoring advantages. This allows securing of preferable positions or manoeuvres to be targeted for strategic advantage and to count towards competitor and/or team scores.

15

For example, there may be stronger or weaker positions on the fighting arena such that, say, the vulnerability of a competitor is greater in a particular position relative to competitors in an opposing team. This is useful for military or security personnel training, or combat training generally – for example, to manipulate positions and manoeuvres (a manoeuvre is a combination of movement (e.g. in position) and attack used) to strategically defend or protect key persons (e.g. a politician or monarch) or to attack a target (e.g. a terror suspect). The incorporation of glyphs into the CGI representation of the fighting arena can provide an additional training means for military or security personnel, including in real time, by allowing the virtual placement of a threat or assistance into the arena. In this way, the scoring system is also useful in entertainment or gaming.

20

25

Motion-sensing means

30 In some embodiments, the scoring system includes motion-sensing means (item 200 in Figure 5) that detects movement and sends data to the scoring machine (or other processing device) regarding movement relating to competition.

Any suitable motion-sensing means can be used, including one or more of the following:

35

- (a) light-based motion sensing means (e.g. laser, infrared, ultraviolet);

- 5 (b) heat-emitting and/or heat-sensing means;
(c) an accelerometer; and/or
(d) any other suitable motion-capture or motion-sensing technology.

10 In some arrangements, the motion-sensing means is configured to detect movement of competitors – say by the inclusion of motion detectors in or on the armor (item 20 in Figure 1). This enables the recording of, for example, the speed (distance / time), magnitude, direction and path of movement of a kick, a strike by a body part (e.g. fist, elbow), a throw or a fall.

15 In other arrangements, the motion-sensing means also detects movement of weaponry or parts of weaponry (e.g. item 25 on Figure 1). For example, in competition combat involving projectile weaponry, e.g. arrows, crossbow bolts, paintballs, motion-sensing means are used to detect and track the trajectory of moving projectiles. In combat involving weaponry such as striking objects (e.g.
20 swords), motion-sensing means on the objects allows the arc of movement of each weapon to be recorded, as well as the speed, direction and path of movement of the weapon. Motion-sensing means can be included on staffs, swords, clubs, shields, projectile weapons (e.g. arrows, crossbow bolts, paintballs), fencing weapons, or any other weapon or object (e.g. baseball bat) suitable for use in the
25 martial arts or fighting arts.

The inclusion of motion-sensing means in the system enables recording and visualisation (e.g. by CGI rendering) of the movement parameters of competitors and/or weaponry. For example, the arc (path), speed (distance / time) and
30 direction of a strike made by a body part, weapon or a projectile is superimposed on video imagery of competition or rendered for viewing on CGI rendering of the fighting arena and competitors. This is useful in enhancing the entertainment value of the viewer experience, as well as providing useful information for training and competition strategy purposes.

35

5 The invention thus provides a new or alternative electronic scoring system,
method and armor for use in martial arts, particularly weapon-focused martial arts
but also useful for martial arts generally, which overcome the problems of prior art
electronic scoring systems, methods and armor in that they provide electronic
means for measuring the potential force, location, duration and direction of any
10 impact while protecting an opponent from a damaging strike that inflicts serious
pain, injury or worse. However, it will be appreciated that the invention is not
restricted to these particular fields of use and that it is not limited to particular
embodiments or applications described herein.

5 CLAIMS

1. An electronic scoring system for use in various styles of martial arts, comprising:

(a) armour to provide impact protection, the armour including a sensing means for detecting force parameter data from one or more forces applied to the armour regardless of an origin of the force, wherein said force parameter data includes data regarding:

- i. magnitude,
- ii. location;
- iii. duration; and
- iv. direction

of one or more forces applied to the armour; and

(b) a scoring machine having:

- i. communication means for receiving the force parameter data from the sensing means;
- ii. tallying means for calculating one or more results using the force parameter data; and
- iii. report generating means for generating one or more reports,

wherein the scoring machine is capable of generating output for display on a visual display.

2. An electronic scoring system for use in various styles of martial arts comprising:

(a) armour to provide impact protection, the armour having a sensing means that is an integral part thereof, the sensing means being

5 configured so that the armour acts as a sensor for detecting force
parameter data of each contact regardless of an origin of the contact,
the sensing means generating a force parameter data signal that is
based on one or more sensed contact forces, wherein said force
parameter data includes data regarding:

- 10 i. magnitude;
ii. location;
iii. duration; and
iv. direction
of one or more forces applied to the armour; and

15 (b) a scoring machine having:

- i. communication means for receiving the force parameter data
signal from the sensing element;
ii. calculation means for calculating one or more results using the
force parameter data; and
20 iii. output means for displaying one or more results,

wherein the scoring machine is capable of generating output for display on a
visual display.

3. An electronic scoring system according to claim 1 or claim 2, wherein the
25 sensing means further includes motion-sensing means that detects movement
data regarding movement of one or more of the following:
a) a competitor;
b) any object associated with the competitor, including one or more of:

- 5 i. a sensor;
- ii. a marker;
- iii. a force-applying member,

 wherein the motion-sensing means communicates the movement data to the
 scoring machine such that the system is capable of detecting movement
10 related to competition.

4. An electronic scoring system according to claim 3 wherein the movement
 data includes data relating to one or more of the following:
- a) speed;
- 15 b) magnitude;
- c) direction;
- d) path
 of movement.

- 20 5. An electronic scoring system according to any one of the preceding claims
 further including position-sensing means for detecting position data of one or
 more of the following:

- (a) a competitor;
- (b) any object associated with a competitor, including one or more of:
- 25 i. a sensor;
- ii. a marker;
- iii. a force-applying member.

5 6. An electronic scoring system according to claim 5, wherein the position data includes data regarding one or more of the following:

- i. motion capture data;
- ii. locating data;
- iii. positioning data.

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7. An electronic scoring system for use in various styles of martial arts comprising:

- (a) armour to provide impact protection;
- (b) at least one first sensing means that is associated with the armour and is configured to measure and record force parameter data of each force applied to the armour regardless of an origin of the force, the first sensing means generating a force parameter data signal that is based on one or more sensed forces;
- (c) at least one second sensing means that is associated with armour and is configured to measure and record data relating to a competitor; and
- (d) a scoring machine having:
 - i. communication means for receiving the force parameter data signal from the first sensing means and the data from the second sensing means;
 - ii. calculation means for calculating one or more results using the force parameter data and the data from the second sensing means; and

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5 iii. output means for displaying one or more results.

8. An electronic scoring system according to claim 7, wherein the first sensing element comprises a force sensing element and the second sensing element comprises one or more of:

10 (a) a motion-sensing means for detecting movement data regarding movement of one or more of:

 i. a competitor;

 ii. a force-sensing element;

 iii. a force-applying member, including one or more of:

15 A. a weapon;

 B. a contact surface used to apply a force;

 C. any other object used to apply a force during competition;

 (b) a position-sensing means for detecting position data including tracking a position of one or more of:

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 i. the competitor;

 ii. a force-applying member;

 iii. any other object associated with the competitor.

25 9. An electronic scoring system according to any one of the preceding claims, wherein the scoring machine is configured to calculate one or more results in the form of a damage value, wherein the results are based on one or more of:

- 5
- (a) force parameter data;
 - (b) movement data;
 - (c) position data.

10. An electronic scoring system according to claim 9, wherein the scoring
10 machine is further enabled to calibrate damage value according to a
physical attribute of:

- (a) an individual competitor;
- (b) a force-applying member, including one or more of:
 - 15 i. an object used to apply the force;
 - ii. a contact surface used to apply the force,

such that the scoring machine is enabled to interpret a result of a contact
force as if the force had been applied by a force-applying member that is
different than the force-applying member actually used to apply the force.

20 11. An electronic scoring system according to any one of the preceding claims,
wherein the armour is divided into segments, each segment of the armour
corresponding to different grid co-ordinates on a scoring grid, such that the
scoring machine is enabled to record a specific location of a force applied to
the armour by reference to the corresponding grid co-ordinates.

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12. An electronic scoring system according to any one of the preceding claims,
further including a response simulation means coupled to the armour, the
response simulation means being activated when the sensing means

5 detects a force of a particular threshold damage value, the damage value being calculated based on one or more of the following:

(a) force parameter data including a combination of two or more of the following:

- i. magnitude;
- 10 ii. location;
- iii. duration; and
- iv. direction

of one or more forces applied to the armour;

(b) movement data; and

15 (c) position data

wherein the response simulation means simulates at least part of the effect on a competitor of being struck by a force of the calculated damage value.

13. 20 An electronic scoring system according to claim 12 wherein the response simulation means is one or more of the following:

- a) light-emitting means;
- b) electric shock-emitting means.

14. 25 An electronic scoring system according to claim 13, wherein the light emitting means is coupled to a helmet-portion of the armour, the light emitting means being activated to flash when the sensing means associated with the helmet-portion of the armour detects a force of a particular threshold damage value, thereby creating a simulation of a reaction from a

- 5 competitor wearing the helmet-portion, the simulation being the light emitting means flashing in the competitor's eyes.
15. An electronic scoring system according to claim 13 wherein the electric shock-emitting means is configured to trigger when a force of a particular
10 threshold damage value is applied to the armour thereby creating a simulation of a reaction from a competitor wearing the armour.
16. An electronic scoring system according to any one of the preceding claims, wherein the system further comprises a computer generated imagery (CGI)
15 means for rendering one or more visual representations of competition, said visual representations being based on one or more of:
- (a) force parameter data;
 - (b) movement data;
 - (c) position data.
- 20
17. An electronic scoring system according to claim 16 wherein said visual representation includes a visual simulation of a damage value of one or more forces applied.
- 25 18. An electronic scoring system according to claim 17, wherein said visual simulation includes an anatomical representation of a competitor's body and a theoretical effect of the force applied, said effect including one or more of the following:

- 5 (a) displacement of a body part in a direction of the force applied;
- (b) breaking of a bone;
- (c) tissue damage;
- (d) organ damage;
- 10 (e) fluid loss;
- (f) reaction by the competitor to damage.

19. An electronic scoring system according to any one of the preceding claims, wherein the tallying means calculates a damage value for each force applied to the armour, the damage value being converted into a scoring advantage or disadvantage, and

15 wherein the damage value is further represented on the visual display by a visual rendering of a force applied to an area on the body, the visual rendering showing a relative distribution of forces across the area.

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20. An electronic scoring system according to any one of the preceding claims, wherein the sensing means comprises a plurality of sensors connected in one or more arrays, each array being connected to the communication means, thereby forming a module that is in communication with the

25 scoring machine.

- 5 21. An electronic scoring system according to claim 20, wherein the system includes a plurality of modules, said plurality of modules being one or more of the following:
- a) weaved through an armour-covering material;
 - b) integrated with the armour.
- 10
22. An electronic scoring system according to claim 21, wherein each module is configured to contact to one or more other modules and wherein a signal is multiplexed and the scoring machine is configured to receive the multiplexed signal and convert the signal back into multiple discrete signals
- 15 from discrete sensors and wherein the signal represents one or more of the following:
- a) force parameter data; and
 - b) movement data.
- 20 23. An electronic scoring system according to claim 22, wherein the sensors are force sensors selected from one or more of the group consisting of piezoelectric sensors, piezoresistive sensors, accelerometers, tactile sensors, and shape memory alloy (SMA) sensors.
- 25 24. An electronic scoring system according to claim 23, wherein the force sensors are linked by tuning means, the tuning means defining a force to voltage relationship for each sensor so that sensitivity of the force sensors is uniform across one or more arrays.

- 5 25. An electronic scoring system according to any one of the preceding claims,
 wherein the sensing means is configured to detect each discrete location
 where a force is applied to the armour.
26. An electronic scoring system according to any one of the preceding claims,
10 wherein the sensing means further includes a switching mechanism to
 enable one or more sensing means elements (sensors) to be switched on
 directly or indirectly when the sensor detects a force, such that the sensing
 means records only from an active sensor rather than monitoring all
 sensors at all times.
- 15 27. An electronic scoring system according to any one of the preceding claims,
 wherein the sensing means is embedded in a skin worn over traditional
 armour.
- 20 28. An electronic scoring system according to any one of the preceding claims,
 wherein the armour includes built-in electronic circuitry for driving at least
 one component of the armour that requires power.
29. An electronic scoring system according to claim 28, comprising at least one
25 of:
 (a) a sensing means;
 (b) a response-simulation means;
 (c) a camera.

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30. An electronic scoring method for use in various styles of martial arts including the steps of:
- (a) detecting force parameter data from one or more forces applied to the armour that is configured to be worn by a user, wherein the armour provides impact protection;
 - (b) communicating the force parameter data to a scoring machine; and
 - (c) calculating a result using the force parameter data,
- wherein the force parameter data includes data regarding:
- i. magnitude;
 - ii. location;
 - iii. duration; and
 - iv. direction
- of one or more forces applied to the armour, regardless of an origin of the force.
31. An electronic scoring method according to claim 30, further including the step of:
- dividing the armour into segments, each segment of the armour corresponding to different grid co-ordinates on a scoring grid such that the scoring machine is enabled to record a specific location of a force applied to the armour by reference to the corresponding grid co-ordinates.
32. An electronic scoring method according to claim 30 or 31 wherein the force parameter data are detected by sensing means from one or more of the

- 5 group consisting of piezoelectric sensors, piezoresistive sensors, accelerometers, tactile sensors, and shape memory alloy (SMA) sensors.
33. An electronic scoring method according to any one of claims 30 to 32, including one or more of the further steps of:
- 10 (a) detecting movement data regarding one or more of:
- i. a competitor;
 - ii. any object associated with the competitor, including one or more of:
 - 15 A. a sensor;
 - B. a marker;
 - C. a force-applying member; and
- (b) detecting position data regarding one or more of:
- i. a competitor;
 - ii. any object associated with the competitor, including one or more of:

20 A. a sensor;

B. a marker;

C. a force-applying member.
- 25 34. An electronic scoring method according to any one of claim 30 to 33 including the further step of calculating a result expressed as a damage value, the result being based on one or more of:
- (a) force parameter data;

- 5 (b) movement data;
 (c) position data.

35. An electronic scoring method according to any one of claims 30 to 34,
including the further step of rendering one or more visual representations
10 of competition using computer generated imagery (CGI), the visual
representations being based on one or more of:
- (a) force parameter data;
 (b) movement data;
 (c) position data;
15 (d) a damage value.

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