

METHOD AND DEVICES TO MEASURE PARAMETERS FOR BOXING PUNCHES OR PUSH ACTIONS

REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Provisional Application No. 63/510,829, filed on June 28, 2023, which is expressly incorporated herein by reference in its entirety.

BACKGROUND

FIELD OF THE DISCLOSURE

[0002] The present disclosure is generally related to force measurement technology, and more particularly to an object for measuring a punch or pushing force applied thereto, such as via a user's fist or hands, as well as other parameters associated with such force. The technology may be incorporated into a number of different objects, which include, but are not limited to, a boxing bag, boxing gloves, and/or a flat screen.

DESCRIPTION OF RELATED ART

[0003] Understanding and improving the speed of a fighter (e.g., martial arts) and/or boxer's punch is known to provide advantages during matches. In addition, measurements related to accuracy of punches and forces as they are applied, as well as reaction time, may improve a user's performance. Similarly, such techniques can be applied to understanding parameters associated with a user's leg kicking.

[0004] Separate methods exist for measuring force and human reaction time to reach a touch event, e.g., a tap on a computer screen or display screen. However, methods and devices for measuring additional parameters related to pushing / punching forces are limited.

SUMMARY

[0005] It is an aspect of this disclosure to provide a system that includes: an object having a plurality of punch zones; and one or more punch measurement devices configured to be provided in the plurality of zones of the object. Each punch measurement device hosts a plurality of sensors therein. The system also includes one or more force sensors configured to generate output signals conveying information related to forces applied to the one or more punch measurement devices. The one or more force sensors are provided in a wearable

device configured to be worn by a user (e.g., boxing gloves, a vest with separate punch zones and attached force measurement devices, etc.). Also, at least one hardware control unit associated with the object and/or the wearable device and a main control unit are provided as part of the system. The at least one hardware control unit has software for data collection and data transfer. The main control unit is connected to the at least one hardware control unit and configured to receive data from one or more of the at least one hardware control unit, each of the one or more punch measurement devices, and the one or more force sensors, and/or other devices. In some embodiments, a punch measurement device and/or a force sensor may provide information to an associated hardware control unit, and the hardware control unit may in turn provide the information to the main control unit. In some embodiments, a punch measurement device and/or a force sensor may provide information directly to the main control unit. There may be some embodiments (e.g., for device initialization, calibration, and/or other operations) where this communication occurs in a reverse direction. In some embodiments, a punch measurement device, a force sensor, and/or a hardware control unit may comprise separate hardware devices. However, in some embodiments, one or more of these devices may be coupled to form a singular hardware block. The main control unit is configured to utilize the received data to determine measurements and calculations associated with the forces applied to the one or more punch measurement devices. Further, an interface is provided as part of the system and is configured to output and display to the user: information, measurements, and calculations determined by said main control unit.

[0006] Another aspect provides a method for measuring punches, such as via the aforementioned system. Such a method may include: providing one or more punch measurement devices in an object, each punch measurement device hosting a plurality of sensors therein; sensing, via one or more force sensors, information related to forces applied thereto, said one or more force sensors being provided in the object and a wearable device; generating output signals conveying the information related to forces applied to the one or more force sensors; collecting and transferring data via at least one hardware control unit associated with the object and/or the wearable device to a main control unit; determining measurements and calculations associated with the forces applied to the one or more force sensors using the main control unit; and outputting and displaying information, measurements, and calculations determined by said main control unit to the user.

[0007] Yet another item provided by this disclosure includes a method and devices for performing multiple measurements of a boxing punch (or a similar push action in other

sports). These measurements provide force, acceleration, reaction time, 3D (e.g. angles (such as Euler and/or other angles), speed, accuracy/precision, rate of force development, straight punch (e.g., jab or cross) efficiency, SPR index (Strength, Precision, reaction time), for example. The devices performing the associated measurements, use one or more force sensors and one or more motion sensors embedded in the boxing gloves and/or in the punched (pushed) object. In case of a flat screen used for punching area and showing an opponent, a set of position sensors can be used to measure the accuracy of the punch (push). These methods and devices can be used in a boxing (or pushing) test, contests, boxing matches, martial art competitions, assessments and training activities, for fitness and exercising games, and/or may have other uses.

[0008] Other aspects, features, and advantages of the present disclosure will become apparent from the following detailed description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a schematic illustration of components of a system according to an embodiment of this disclosure.

[0010] FIG. 2 illustrates a schematic representation of an object (e.g., a punching bag in this example) and wearable device (e.g., a boxing glove in this example) that may be part of the system of FIG. 1 according to an embodiment of this disclosure.

[0011] FIG. 3 is a schematic drawing of a measurement device used in the system of FIG. 1, according to an embodiment of this disclosure.

[0012] FIG. 4 shows how the geometry of a punch force is defined by this disclosure, said geometry configured for use by the system for providing output in accordance with embodiments herein.

[0013] FIG. 5 illustrates examples of timelines for two punch combinations that may be implemented by the system according to embodiments herein.

[0014] FIG. 6 illustrates examples of information that may be provided to a user via a display (on the user's smartphone in this example, according to embodiments herein).

[0015] FIG. 7 illustrates method for measuring punch or push parameters, according to embodiments herein.

DETAILED DESCRIPTION OF EMBODIMENT(S)

[0016] Embodiments of this disclosure will now be described in detail with reference to the drawings and pictures, which are provided as illustrative examples so as to enable those skilled in the art to practice the invention. Notably, the figures and examples below are not meant to limit the scope of this disclosure to a single embodiment, but other embodiments are possible by way of interchange of some or all of the described or illustrated elements. Wherever convenient, the same reference numbers will be used throughout the drawings to refer to same or like parts. Where certain elements of these embodiments can be partially or fully implemented using known components, only those portions of such known components that are necessary for an understanding of the present invention will be described, and detailed descriptions of other portions of such known components will be omitted so as not to obscure this disclosure. In the specification, an embodiment showing a singular component should not be considered limiting; rather, this disclosure is intended to encompass other embodiments including a plurality of the same component, and vice-versa, unless explicitly stated otherwise herein. Moreover, applicants do not intend for any term in the specification or claims to be ascribed an uncommon or special meaning unless explicitly set forth as such. Further, this disclosure encompasses present and future known equivalents to the components referred to herein by way of illustration. Other and further aspects and features will be evident from reading the following detailed description of the embodiments, which are intended to illustrate, not limit, this disclosure.

[0017] As used herein, the singular form of “a”, “an”, and “the” include plural references unless the context clearly dictates otherwise. As used herein, the term “or” means “and/or” unless the context clearly dictates otherwise.

[0018] Directional phrases used herein, such as, for example and without limitation, top, bottom, left, right, upper, lower, front, back, and derivatives thereof, relate to the orientation of the elements shown in the drawings and are not limiting upon the claims unless expressly recited therein.

[0019] As evident by the drawings and below description, this disclosure relates to a method and devices for measuring parameters such as force, reaction time, speed, accuracy, and efficiency for boxing punches and/or other push actions upon a surface. For example, the method and devices presented herein have the following non-limiting features:
-ability to obtain a comprehensive set of multiple related measurements and determinations such as force, acceleration, reaction time, three dimensional (3D) angles, punch speed, accuracy/precision, rate of force development, straight punch (jab or cross) efficiency, etc.;

- ability to measure reaction time, applicable to both actions: to punch or push an object;
- use of at least four types of reaction time measurements: Target-Force Reaction Time, Initial Reaction time, Acceleration Reaction time, and Protection Reaction time;
- ability to obtain punch efficiency estimate and compound estimate(index) for Strength, Precision, and Reaction time (SPR);
- use of sensors in boxing gloves to:
 - track motion and transmit raw accelerometer and gyroscope data to a computer or main control unit over the air; and/or
 - determine which part of the glove was involved in applying force (punch), measure this force and a 3D (e.g. Euler) angle of force application;
- use of sensors in or on the punched (pushed) object to measure force and acceleration on this target object / boxing bag; and/or
- establish a radio link and correlate the sensor data in the glove with the target / boxing bag sensor data.

[0020] Throughout this disclosure, there is reference to a “punch” or punch force, such as used in the sport of boxing. The term “punch” is intended to refer to an application of force, or push force, by a user and not intended to be limited to a force provided by a user’s closed fist; rather, a punch or push force may refer to any number of applied forces that are similar thereto, such as via a user’s palm, finger(s), thumb(s), feet, leg(s), and other extremities. Similarly, while there is reference to the sport of boxing and equipment used for boxing, one skilled in the art should and will understand that the system, devices, and methods disclosed herein may be utilized in other applications, including, but not limited to, physical therapy, occupational therapy, and martial arts (including mixed martial arts).

[0021] FIG. 1 schematically represents components of a system 100 according to an embodiment of this disclosure. The system 100 includes a network 102, one or more sensors 104, one or more processors 106 (e.g., hardware control units) and/or one or more controllers, one or more output devices 108, one or more computing devices 110 (e.g., main control units), and/or other components 116. As described above, in some embodiments, a computing device 110 (e.g., a main control unit) is connected to and/or includes a processor 106 (e.g., a hardware control unit) and is configured to receive data from one or more of the at least one hardware control units, each of the one or more punch measurement devices (e.g., a device with and embedded (first) sensor 104), and/or the one or more force sensors (e.g., a second standalone sensor 104), and/or other devices. In some embodiments, a punch

measurement device and/or a force sensor (e.g., one or more sensors 104) may provide information to an associated hardware control unit (e.g., a processor 106), and the hardware control unit may in turn provide the information to the main control unit (e.g., a computing device 110). In some embodiments, a punch measurement device and/or a force sensor may provide information directly to the main control unit. There may be some embodiments (e.g., for device initialization, calibration, and/or other operations) where this communication occurs in a reverse direction. In some embodiments, a punch measurement device, a force sensor, and/or a hardware control unit may comprise separate hardware devices. However, in some embodiments, one or more of these devices may be coupled to form a singular hardware block. Each of these components is described in turn below.

[0022] Network 102 may include the Internet, a Wi-Fi network, Bluetooth® technology, cellular network, radio linkage, and/or other wireless technology. In embodiments, sensors 104, one or more processors/controllers 106, one or more output devices 108, one or more computing devices 110, and/or other components of system 100 communicate via near field communication, Bluetooth®, and/or radio frequency via network 102, and/or by other communication methods.

[0023] Sensors 104 are provided to sense data and generate one or more output signals comprising information related to a force(s), such as a punch force or a pushing force. In embodiments, sensors 104 are provided in multiple devices and their output data may be kept separate or combined (e.g., via calculations) to determine parameters associated with such force(s). In embodiments, the output signals from said sensors 104 include, but are not limited to, force, acceleration, time, angle(s), speed and/or velocity, position, rotation, and orientation, and other parameters or features. Such data and signals, including how they are utilized, are further described later below. Sensors 104 may be a chip-based sensor according to an embodiment. Sensors 104 may include accelerometers, gyroscopes, GPS and/or other position sensors, force sensors, magnetometers, timers, and/or other sensors. The sensed data / information may be used by processor(s) / controller(s) 106 (described below) to determine an acceleration and/or velocity/speed, angular movement, and/or other information about each of the sensors 104 in system 100. This information may be used by the computing device(s) 110 to output results via output device 108 and to alter directions to a user providing the force / punch force (as described below), and/or for other purposes.

[0024] One or more processors and/or controllers 106 are configured to provide data / information processing capabilities in system 100. As such, processor(s) / controller(s) 106

may include one or more of a digital processor, an analog processor, a digital circuit designed to process information, an analog circuit designed to process information, a state machine, and/or other mechanisms for electronically processing information. As described above, processor(s)/controller(s) in this disclosure may be referred to as a (e.g., hardware) control unit, or CU 106 (such as shown and described with reference to FIG. 2), which may comprise hardware and/or software and is not intended to be limiting. In some embodiments, one or more CUs 106 may be included in and/or otherwise operatively coupled with each of, or a set of, sensors 104, output device(s) 108, computing device(s) 110, and/or other components of system 100. Although one or more processors / CUs 106 are shown in FIG. 1 as a single entity, this is for illustrative purposes only. As will become evident later below, in some implementations, processor(s) / CU(s) 106 may include a plurality of processing units. These processing units may be physically located within the same device (e.g., a punched object 10, such as a punching bag, a vest, a screen, etc.) described with reference to FIG. 2), punch or push devices 20 (FIG. 2), output device(s) 108, computing device(s) 110, etc.), or processor(s) / CU 106 may be represented by providing processing functionality in multiple devices operating in coordination with one another (e.g., a processor(s) / controller(s) located within an object 10 and/or sensors 104 therein, and an additional processor(s) / controller(s) located within another (wearable) device (40), in one or more punch or push devices 20, and/or computing device 110). Each CU 106 may be configured to execute one or more computer program components. Each CU 106 may be configured to execute the computer program component by software; hardware; firmware; some combination of software, hardware, and/or firmware; and/or other mechanisms for configuring processing capabilities on processor(s)/CU(s).

[0025] In embodiments, the one or more processors / CUs 106 are configured by machine readable instructions (for instance software and/or firmware) to process the sensor output signals to convert and/or amplify the information related to the forces to produce a voltage signal. The system may be configured to process (e.g., convert voltages into) force values (and other parameters) associated with the sensor output signals. In some embodiments, the system is configured to communicate the processed sensor output signals to a remote computing device, such as computing device 110. In some embodiments, the computing device 110 is configured to receive and process multiple sensor output signals and determine force values and other parameters associated with the sensor output signals, as described below with reference to FIGS. 4 and 5.

[0026] Output device(s) 108 is configured to generate output regarding data, instructions, determinations, calculations (e.g., data to present to a user to instruct said user on an action to take as determined by computing device 110, and/or data as determined by computing device 110 via data received from sensors 104 and/or CU 106), and/or other information. Output device(s) 108 is configured to provide output to a user, a boxer, a trainer, a fighter, and/or other users. Output device(s) 108 is configured to provide auditory, visual, electric, magnetic, haptic, and/or other output, which may include auditory output, visual output, tactile output, a combination of these and/or different types of output, and/or other output. Examples of an output device 108 may include one or more of a sound generator, a speaker, one or more light generators or lamps, one or more light emitting diodes, a display screen, a touchscreen, and/or other devices. More than one output device 108 may be utilized in system 100. In some embodiments, output device 108 is associated with or provided as part of computing device 110. Further, as described below, a number of different types of output devices 108 may be associated with other parts of the system 100.

[0027] One or more computing devices 110 may be and/or include a smartphone, a laptop computer, a tablet, a desktop computer, a gaming device, and/or other networked computing devices, each having a display, a user input device (e.g., buttons, keys, voice recognition, or a single or multi-touch touchscreen), memory 112 (such as a tangible, machine-readable, non-transitory memory), a network interface, an energy source and/or power source (e.g., a battery), electronic storage 114, and a processor coupled to each of these components, and/or other components. Memory 112 and/or electronic storage 114 of computing device 110 may store instructions that when executed by the associated processor provide an operating system and various applications, including a web browser or a native mobile application, for example. In addition, computing device 110 may include a user interface 118, which may include a monitor; a speaker; a keyboard; a mouse; a touchscreen; etc.. Such a user interface 118 may be operative to provide a graphical user interface associated with the system 100 that communicates with sensors 104, output device 108, and/or processor(s) / CU 106, and facilitates user interaction.

[0028] A computing device 110 may include one or more processors coupled to system memory 112 (which may be similar to and/or the same as electronic storage 114), an input/output I/O device interface, and a network interface. In embodiments herein, computing device 110 is also referred to as a main control unit, or MCU 110. MCU 110 may include a central processing unit (CPU) that carries out program instructions to perform the

arithmetical, logical, and input/output operations of the computing device. MCU 110 may execute code (e.g., processor firmware, a protocol stack, a database management system, an operating system, or a combination thereof) that creates an execution environment for program instructions. MCU 110 may include a programmable processor. MCU 110 may include general or special purpose microprocessors. MCU 110 may receive instructions and data from a memory 112 and/or storage 114 as well as sensors 104 via CU(s) 106. MCU 110 may be a single processor system or a multi-processor system. Methods and processes, such as logic flows, described herein may be performed by one or more programmable processors of MCU 110 executing one or more computer programs to perform functions by operating on input data and generating corresponding output.

[0029] Memory 112 and/or storage 114 may be configured to store program instructions (e.g., machine readable instructions) and/or data. Program instructions may be executable by a processor associated with MCU 110 to implement one or more embodiments of the present techniques. Instructions may include modules and/or components of computer program instructions for implementing one or more techniques described herein with regard to various processing modules and/or components. Program instructions may include a computer program (which in certain forms is known as a program, software, software application, script, or code). A computer program may be written in a programming language, including compiled or interpreted languages, or declarative or procedural languages. A computer program may be deployed to be executed on one or more computer processors located locally at one site or distributed across multiple remote sites and interconnected by a communication network, such as network 102.

[0030] Memory 112 and/or storage 114 may include a tangible program carrier having program instructions stored thereon. A tangible program carrier may include a non-transitory computer readable storage medium. A non-transitory computer readable storage medium may include a machine readable storage device, a machine readable storage substrate, a memory device, or any combination thereof. Non-transitory computer readable storage medium may include non-volatile memory (e.g., flash memory, ROM, PROM, EPROM, EEPROM memory), volatile memory (e.g., random access memory (RAM), static random access memory (SRAM), synchronous dynamic RAM (SDRAM)), bulk storage memory (e.g., CD-ROM and/or DVD-ROM, hard-drives), or the like. Memory 112 and/or storage 114 may include a non-transitory computer readable storage medium that may have program instructions stored thereon that are executable by a computer processor to cause the

subject matter and the functional operations described herein. A memory 112 may include a single memory device and/or a plurality of memory devices. A storage 114 may include a single storage device and/or a plurality of storage devices. Instructions or other program code to provide the functionality described herein may be stored on a tangible, non-transitory computer readable media.

[0031] Storage 114 may include electronic storage media that electronically stores information. The electronic storage media of electronic storage 114 may include one or both of system storage that is provided integrally (i.e., substantially non-removable) with system 100 and/or removable storage that is removably connectable to system 100 via, for example, a port (e.g., a USB port, a firewire port, etc.) or a drive (e.g., a disk drive, etc.). Electronic storage 114 may include one or more of optically readable storage media (e.g., optical disks, etc.), magnetically readable storage media (e.g., magnetic tape, magnetic hard drive, floppy drive, etc.), electrical charge-based storage media (e.g., EEPROM, RAM, etc.), solid-state storage media (e.g., flash drive, etc.), and/or other electronically readable storage media. Electronic storage 114 may store software algorithms, information determined by processor(s) 106, information received via user interface 118, and/or other information that enables system 100 to function properly. Storage 118 may be (in whole or in part) a separate component within system 100, or electronic storage 118 may be provided (in whole or in part) integrally with one or more other components of system 100 (e.g., computing device 110).

[0032] MCU 110 is configured to be and may be communicatively connected to all devices / components associated with system 100, wirelessly and/or using wires (in any combination – i.e., MCU 110 may be wired to one or more other components of the system and also communicate wirelessly over a network (e.g., 102) with one or more different components).

[0033] In some embodiments, MCU 110 is configured to execute a trained machine learning model to provide data and parameters associated with a punch force (e.g., including, but is not limited to, recognizing a punch type, accuracy of one or more punches, an angle of a punch, and the like), determine estimations and/or calculations using said data, and providing altered instructions to a user for providing punch force, based on the signals received from sensors 104 and/or CU(s) 106. Similarly, altered instructions that are provided via MCU machine learning may include to change a punch type, a punch location or target, an angle of a punch, et al., which may (or may not) include changing and/or updating a

training routine / workout for the user. In some embodiments, MCU 110 are configured to cause a machine learning model to be trained using training information. In some embodiments, the machine learning model is trained by providing the training information as input to the machine learning model. In some embodiments, the machine learning model may be and/or include mathematical equations, algorithms, plots, charts, networks (e.g., neural networks), and/or other tools and machine learning model components. For example, the machine learning model may be and/or include one or more neural networks having an input layer, an output layer, and one or more intermediate or hidden layers. In some embodiments, the one or more neural networks may be and/or include deep neural networks (e.g., neural networks that have one or more intermediate or hidden layers between the input and output layers).

[0034] According to embodiments, either one or more processors 106 or MCU 110, or both, are configured to control one or more output devices 108 to generate an audio and/or visual signal to a user (or boxer, or trainer, etc.), to perform an action, such as providing a punch force in a designated area. Control may comprise electronic communication of one or more commands to an output device 108, and/or other control operations. In some embodiments, one or more processors 106 and/or MCU 110 are configured to cause output device 108 to output a sound and/or tone, illuminate a light or a light emitting diode (LED), display an action or trigger on a display screen, and/or facilitate other functionality. In some embodiments, each visual indicator (as non-limiting examples: light, LED, text on a computer screen), is used to indicate a specific target zone and/or specific required punch type: for example, a straight punch, left hook punch, right hook punch or uppercut punch, as described herein. The actual punched or pushed zone and/or punch type are detected using sensors and are compared to the indicated target zone and/or expected punch type, and a statistical report is produced to track the punch accuracy related to a target zone and/or expected punch type. The target zones and/or punch types may be indicated in a sequence (combination) in time, by a main control unit, where the sequence has different zones (devices) to punch, random or predefined periods between indicated targets, and the sequence is programmable and adjustable.

[0035] In FIG. 1, sensors 104, one or more processors 106 and/or one or more controllers, an output device 108, one or more computing devices 110, and/or other components of system 100 are shown as separate entities. This is not intended to be limiting. Some and/or all of the components of system 100 and/or other components may be grouped

into one or more singular devices. For example, sensors 104 may be grouped together with CUs 106. As another example, output device 108 may be included in or as part of computing device 110. These and/or other components may be included in a wearable [device or object] worn by a user or other device. As described in FIG. 2 below, more than one wearable may be provided in system 100 and such wearable(s) may include one or more of sensors 104, processor(s) / CU(s) 106, and/or output device 108. The wearable(s) may be a vest, garment, a device, and/or other wearables like boxing mitts (training pads held by a trainer) that have embedded devices with CUs, force and motion sensors. The trainer can make a gesture like “pad up”, that requires an immediate punch by the boxer. In such case the MCU can track the mitt motion data, detect the gesture, start a timer, track the wearable glove force and motion data, detect a punch and calculate a target force reaction time, and target acceleration reaction time of this new punch. In embodiments, the wearable(s) may include means to deliver sensory output (e.g., a wired and/or wireless audio device and/or other devices) such as one or more audio speakers. Further examples of implementing the system features and types of wearable(s) will be understood by the description below.

[0036] User interface 118 is configured to provide an interface between system 100 and users (e.g., a boxer, a trainer, a fighter, etc.) through which users may provide information to and receive information from system 100. This enables data, results, and/or instructions, and any other communicable items, collectively referred to as “information,” to be communicated between the users and one or more of sensors 104, CU(s) 106, output device(s) 108, computing device 110, and/or other components 116. Examples of interface devices suitable for inclusion in user interface 118 include a display screen, a touch screen, a keypad, buttons, switches, a keyboard, speakers, a microphone, an indicator light, an audible alarm, music, and/or other interface devices. In one embodiment, user interface 118 includes a plurality of separate interfaces (e.g., an interface associated with sensors 104 (or sets of sensors), an interface on output device 108, an interface in computing device 110, etc.). In one embodiment, user interface 118 includes at least one interface that is provided integrally with MCU 110. It is to be understood that many communication techniques, either hard-wired or wireless, between one or more components of system 100 are contemplated by the present disclosure.

[0037] The illustrated components of system 100 are depicted as discrete functional blocks, but embodiments are not limited to systems in which the functionality described herein is organized as illustrated by FIG. 1. The functionality provided by each of the

components of system 100 may be provided by software or hardware modules that are differently organized than is presently depicted, for example such software or hardware may be intermingled, broken up, distributed (e.g. within a data center or geographically), or otherwise differently organized. Some or all of the functionality described herein may be provided by one or more processors of one or more computers executing code stored on a tangible, non-transitory, machine readable medium.

[0038] FIG. 2 is a schematic representation of features included in the disclosed system, and methods of using the same. As shown in FIG. 2, system 100 includes: an object 10 having one or more punch zones 12 (illustrated are zones 12a, 12b, 12c, and 12d) and one or more punch or push measurement devices 20 (also referred to as force measurement devices herein) configured to be provided in the plurality of punch zones 12a, 12b, 12c, and 12d of the object. As noted later, in an embodiment, the punch or push measurement devices 20 may be positioned in designated area 14 (illustrated are areas 14a, 14b, 14c, and 14d) within each of the punch zones 12a, 12b, 12c, and 12d. In one embodiment, the areas 14a, 14b, 14c, and 14d are provided in the form of pockets. In the illustrated embodiment, there are four punch zones 12a-12d shown associated with the object 10, e.g., upper left, upper right, lower left, and lower right. The naming of the zones is not intended to be limiting, but instead to indicate an area that may be used, for example, in a software application to provide feedback (e.g., via interface 108, described later). In a non-limiting example, the one or more punch zones 12 can be named after target punch types such as: 1) straight punch up in the middle, 2) hook left up and 3) hook right up, and 4) lower zone: uppercut in the middle. Each area 14a, 14b, etc. is positioned in one of the respective zones 12a, 12b, etc. Such are exemplary only. It should be noted that while the drawings and description refer to four punch zones and areas, the number of punch zones and areas, and thus, number of punch measurement devices therein, are not intended to be limited. In an embodiment, the object 10 may include one or more punch zones and one or more areas. In another embodiment, multiple areas 14 and/or multiple measurement devices 20 may be provided in each particular punch zone 12. Further, placement of the punch zones 12, the areas 14, and the measurement devices 20 are exemplary in FIG. 2 and not intended to be limiting in any way.

[0039] In accordance with some embodiments, there may be four punch zones and a device associated with each zone. Four zones and a device associated with each zone is a representative example of many other possible configurations (e.g., more or less zones, more or less devices, devices associated with more than one zone, etc.) In this example, when the

devices are connected to the MCU 110 (or an app running on it), the MCU 110 (e.g., via instructions provided for display and/or sound through the app) is capable of assigning each device to a particular zone (or zones), or its “zone ID”. In one embodiment, when the system is being set up, a trainer or user may start with an upper right portion and then connect each device to its assigned quadrant or punch zone in an anti-clockwise direction, such that each device is assigned a zone ID (i.e., to the particular zone it is placed in with regards to the object 10). In a non-limiting embodiment, the connection and association of a device with a particular punch zone may be confirmed via a display (e.g., color), a sound, a combination of both, and/or another signal as an indicator. The system has a matrix to assign each device with a name, confirm a switch is ON, and then connect and associate each device with the punch zone where it is placed to assign its zone ID, for example.

[0040] Each measurement device 20 hosts a number of sensors 22 therein, as shown and described later with reference to FIG. 3, which are part of sensors 104 of FIG. 1. The sensors 104 of the system 100 also include sensors 30, which may include one or more force sensors 30, configured to generate output signals conveying information related to forces applied to the one or more punch or push force measurement devices 20. One or more of the sensors 22 and/or 30 may be provided in the form of chips within their respective devices. Typically, each of the sensors 22 and/or 30 is configured to output information to CU 106 and/or to MCU 110 directly. In some embodiments, each of the sensors 22 is configured to receive a command signal or message (e.g., for initialization, configuration, calibration, and/or other purposes) and/or other signals from CU 106 and/or MCU 110.

[0041] In some embodiments, the sensors 30 are provided in a separate, wearable device 40 configured to be worn by a user. In FIG. 2, the wearable device 40 is shown in the form of a boxing glove. However, this is exemplary only. In an embodiment, the wearable device 40 may be provided in the form of training gloves, half gloves, or boxing gloves. That is, the sensors 30 may be provided in a set and the set included in each (e.g., two) of the gloves, so that each glove is configured to generate output signals. Force sensor(s) of the sensors 30 within wearable device 40 rely on and/or include one or more force sensing technologies. Applicable force sensing technologies may include, but are not limited to, force sensing resistors, load cells using strain gauges, displacement sensors (such as linear variable differential transformer (LVDT) devices, Hall Effect sensors and optical sensors), piezoresistive sensors and/or pressure sensors. Load cells may also be referred to as force sensors. The force sensors generate output signals conveying information used to determine

force values for the force applied. As an example, two wearable devices (e.g. boxing gloves) named “left” and “right” may be used, known to the MCU 110 (or the app running on it), such that the individual device/glove punch forces and sensor data are tracked in time and reports are produced to compare forces, punch speed, punch accuracy or other parameters. In some embodiments, the two wearable devices with embedded sensors (e.g. boxing gloves) calculate or provide periodic sensor data to a main control unit (e.g. computer) to calculate current and/or maximum force, total summed up force, motion-related and other parameters (like speed, acceleration) in a free mode without indicated target points to the user, where the user decides when and how to punch (or push) a physical object (like a boxing bag), or punches in the air (non-limited examples: martial arts or boxing).

[0042] In embodiments, the wearable device 40 further includes one or more motion sensors (as part of sensors 30) embedded therein. According to embodiments, such motion sensors may include accelerometers, angular velocity sensors, magnetometer, and/or timing sensors (or timing devices, or timers), and/or a combination thereof, provided in the wearable device 40. Such motion sensors may provide data along with force sensors to CU 106 in the wearable device 40 such that further determinations and/or calculations may be made, such as with regards to a geometry of a punch as applied by a user to the object 10 (i.e., a measurement device 20), which is further described later.

[0043] The sensors 30 may be 3-axis type sensors (e.g., MEMS sensors) that measure in the x, y, and z axes, according to embodiments herein. Each of the sensors 30 is configured to send a signal to CU 106 and/or MCU 110. Further, in some embodiments, the wearable device 40 may include a power supply (e.g., battery) which is operated and/or initiated via a switch, for example. The force and motion sensors 30, the power supply, and an optional electronics assembly (e.g., CU 106) may be enclosed, embedded, or incorporated into wearable device 40.

[0044] Additionally, the system 100 includes at least one hardware control unit 106 (or CU 106) associated with the object 10 and/or the wearable device 40 and a main control unit 110 (or MCU 110). The at least one hardware control unit 106 has software for data collection and is configured for data transfer (e.g., sending collected data). In the exemplary, non-limiting embodiment of FIG. 2, a CU 106 is shown in the wearable device 40, with an optional one or more CU(s) 106 associated with the object 10 and/or measurement devices 20. The main control unit 110 is connected to the at least one hardware control unit 106 and configured to receive data from the at least one CU 106, each of the one or more punch or

push measurement devices 20, and/or the data originating from one or more force sensors 30. The CUs 106 and/or MCU 110 is/are configured to utilize the received data to determine measurements and calculations associated with the forces applied to the one or more punch or push measurement devices 20. The MCU 110 may be connected to multiple CUs 106 for receipt and gathering of data and/or calculations. In an embodiment, such as described previously with regards to FIG. 1, the main control unit 110 may be provided in the form of a computer or a mobile device. The use of the computer allows for a remote control or multi-user access to the system 100, for example.

[0045] A CU 106 is configured to provide any number of functions as previously described above with respect to FIG. 1. In embodiments, CU 106 is configured to process signals to convert and/or amplify information related to punch forces (e.g. voltage) and produce digitized force data. In embodiments, CU 106 may be configured to communicate processed sensor output signals from sensors 22 and/or sensors 30 to MCU 110 using a wired connection, or via a wireless communication link (see, e.g., CL 58 in FIG. 2) using a wireless communication protocol. CU 106 may be configured to communicate via Bluetooth®, a Wi-Fi connection, and/or other connections, according to embodiments and present information in real time, via a software / web application or server. MCU 110 may be a remote computing device, according to embodiments. In other embodiments, a CU 106 may be configured to communicate the processed sensor output signals to an MCU 110 in the form of a remote device, e.g., communicate via a cloud server / server using a wireless communication link between the CU and the cloud server / server, or communicate via a wired connection. A person of ordinary skill in the art will readily recognize that the foregoing embodiments are not limiting, and that, for instance, wired connections may be substituted for any of the wireless links or vice versa without deviating from the scope of the invention.

[0046] Further, an interface 118 (FIG. 1) and/or output device 108 is provided as part of the system 100 and is configured to output and display information, measurements, and calculations determined by the MCU 110 to the user. According to embodiments, MCU 110 may be configured to send/receive data from a server and/or database and communicate with CU 106. MCU 110 may be provided in the form of a computer or mobile phone, visual and/or audio devices (e.g., lamps, screens, speakers) that are separate from the object 10, according to embodiments herein. In other embodiments, MCU 110 is provided in the form of a server (or cloud server) or other computing device that wirelessly sends and receives information, performs calculations, and then sends data to display on output device 108. In

yet other embodiments, as previously mentioned, a local wireless connection may be provided between CU 106 and MCU 110. The interface 118 and/or output device 108 comprises visual and audio tools (e.g., lamps, screens, speakers) for real time or statistical summary information regarding the data obtained by the object 10 and measurement devices 20 (and the sensors associated therewith). For example, the system 100 may operate in conjunction with a local device such as personal mobile or a remote server (e.g., which may be wireless but local, or a cloud server); a remote application running on a remote Internet device (MCU 110) such as a personal mobile device or computer, mobile phone, tablet or other personal computing device that includes said interface 108. Such an application may be implemented via a Wi-Fi connection, according to embodiments. In embodiments, a remote connection is established via a Wi-Fi driver. The measurement devices 20 and wearable device 40 communicate with the application, which together may operate as a combined system. Each force measurement device 20 is capable of converting, in real-time, the repeated forces applied to the device into digital measurements and then communicates with the remote device in real-time to provide a user with information about the force the user is applying to the device. Similarly, each wearable device 40 is capable of converting, in real-time, the repeated forces applied by the wearable device 40 and/or acceleration and/or angular velocity detected (via sensors 30) into digital measurements and then communicate with the remote device in real-time to provide a user with information about the force and/or acceleration the user is applying from the wearable device 40. The system is configured to allow users to interact with various applications (e.g., fitness, gaming, physical therapy, biometrics, historical comparisons, calories expended, multi-user experiences and/or other applications) by applying force onto the force measurement devices 20.

[0047] According to embodiments, the object 10 may be provided in the form of boxing bag, a boxing surface, and/or a flat or oval/bent screen. The boxing bag may be a simple or anthropomorphic (resembling a human body) type boxing bag, for example. In other embodiments, the object 10 may be a wearable item, such as, but not limited to, a vest, a shirt, and pants. In this disclosure, “wearable” may refer to a user wearing a device or another object wearing a device. For example, in an embodiment, the object 10 may be a punch vest that is worn by (i.e., securely placed around or onto) a boxing bag. In another embodiment, the vest may be worn by another user, a boxer, or a sparing partner of a boxer or a fighter. In some embodiments, the object 10 may be wired to another object (e.g., boxing bag) to assure low voltage power and/or data communication therebetween. In some

embodiments, the object 10 may be the flat or oval/bent screen. The screen may comprise a display and/or other components configured to display various images and/or other information associated with system 100 (e.g., display of an opposing boxer or similar as one example).

[0048] In embodiments, the one or more punch or push measurement devices 20 may be attached or inserted into the object 10. For example, measurement devices 20 may be inserted into pockets at areas 14a, 14b, etc. In an exemplary embodiment, wherein the object 10 is provided in the form of a punch vest, the vest may include a number of transparent and separate identified pockets where measurement devices 20 may be placed individually in a way that is visible to the boxer or user.

[0049] In other embodiments, the one or more punch or push measurement devices 20 may be embedded within the object 10. For example, the punch measurement devices may be secured or sewn between an outer fabric and an inner fabric of the object 10.

[0050] FIG. 3 shows a schematic example of punch or push measurement device 20 used in the system shown in FIG. 2, according to an embodiment of this disclosure. According to embodiments, the sensors 22 of each punch or push measurement device 20 may include force sensors 24, linear acceleration sensors 25, angular velocity sensors 26, magnetometer 27, and/or timing sensors 28 (or timing devices, or timers), a combination thereof, and/or other sensors. In addition to these types, in order to calculate distance and then speed of a glove (hand or leg), the following sensors can be used as part of sensors 22: optical (such as structured light), lidar, electro-magnetic (radar), or electro-static (distributed capacitance) based motion sensors. Each of the sensors 22 is configured to send a signal to CU 106 and/or MCU 110. According to embodiments, CU 106 is configured to collect data from sensors 22 and communicate such data to the MCU 110.

[0051] Each measurement device 20 is configured to communicate information related to coordinate system axes (x, y, z). Additionally, via CU 106, each wearable device 40 (e.g., boxing glove) is configured to communicate information via corresponding x, y, z axes. In an embodiment, the CU 106 may include an embedded IMU chip. The CU 106 in wearable device 40 may be utilized to measure and determine a geometry of a punch, e.g., punch type, angle, punch direction, punch rotation, etc., such as illustrated in FIG. 4, using data from sensors 30. In particular, FIG. 4 illustrates exemplary measurements and calculations performed via the CU 106 in the wearable device 40 (e.g., glove). For example, measurements may be performed using an Euler angle calculated by a Kalman filter to

measure a punch angle (α , which corresponds to glove pitch or inclination) and punch direction (β), as well as rotation of the wearable device 40, as a punch is directed towards a target measurement device 10. Another approach to obtain angles, is to convert quaternions to radian angles. The determinations and/or calculations may be communicated to the MCU 110 for display via output device 108, e.g., using a mobile / web application. In some embodiments, determinations and/or calculations may be performed at MCU 110, in addition to, or alternative to, CU 106 in wearable device 40.

FIG. 4.

[0052] In some embodiments, the system 100 is configured to convert, in real-time, analog signals conveying information related to repeated forces exerted upon the measurement device(s) 20 into digital measurements, determinations, and/or calculations, wherein the one or more processors (CU 106 and/or MCU 110) are configured by machine readable instructions to provide real-time information to the user (e.g., via output device 108 and/or user interface 118) regarding the force applied to the measurement device(s) 20 and other related parameters. In embodiments, executing machine readable instructions cause the CU 106 and/or MCU 110 to process the sensor output signals to convert and/or amplify the information related to punch forces to produce signal(s), electronic messages, and/or other information, and communicate such signal(s), messages, and/or other information to a remote computing device not housed by a housing, object, or wearable device.

[0053] In an non-limiting embodiment, the App / MCU 110 may display via output device 108 data regarding the punch angle (as calculated per details shown in FIG. 4 of a punch, for example. Calculations / determinations of the Euler angles in each of the three (e.g., x, y, and z) rotation axes may be displayed, for example, as well as accelerometer data (G) and gyroscope data (deg/s) in each of the three axes may also be displayed. In embodiments, a calculated straight punch (jab or cross) reaction time, a punch speed (for example), a punch speed, and/or other information may be displayed via output device 108.

[0054] In embodiments, the one or more punch or push measurement devices 20 may each comprise an output device 108 such as an audio sound device and/or visual indicator, represented as 55. A visual indicator may be a light indicator, according to some embodiments. In some embodiments, each of the punch or push measurement devices 20 may include a visual indicator provided in the form of an LED or screen. For example, such audio and/or visual indicators may be utilized in a manner that indicates to the user the zone 12 or area 14 to punch with a punching force. A signal may be issued (e.g., by MCU 110) for the

user to perform a punch. Such a signal may be an audio (e.g., voice, sound, or alarm issued by a speaker) or visual indication (e.g., a color change or a new image on a computer screen visible by the boxer, a singular LED or array (linear or planar) of LEDs on the target/bag, an image projected on the target/bag, a laser dot projected on the target/bag, a flexible screen integrated in the bag). The signal indication requires a punch or a push onto a particular place on the designated object 10. Punching of the correct or incorrect target may be indicated via a change of an LED color or turning off an LED, for example. This may also be indicated by a separate type of audio signal to the user and/or may comprise other indications.

[0055] According to embodiments herein, the timing devices or timers provided in the punch or push measurement devices 20 and object 10 may be utilized for a number of reasons, including to obtain raw data from corresponding sensors (in each respective object/device) for sending to the MCU 110 as well as to implement a time blinking schedule, e.g., via indicators 55, for one or more punch combinations to presented to a user, which is described in greater detail below and shown in FIG. 5.

[0056] Each measurement device 20 may be provided with a housing 21 that is formed from any number of materials. In embodiments, such a housing 21 may include relatively hard plastic shells that flank a softer rubber surface (e.g., TPE layer) of approximately 1.0-1.5 mm thickness, allowing for flexibility between the outer shells, for example. The housing has at least one surface region configured to receive the punch force(s) exerted thereupon. Circuitry, sensors, and the like may be housed in the housing thereof. The surface region(s) may include shape(s) that are moveable responsive to application of the punch forces applied thereto. As a result, the sensors generate output signals to convey information related to the punch forces applied thereto.

[0057] As mentioned previously, a CU 106 may be designed to communicate with MCU 110 in a number of ways. In an embodiment, each punch or push measurement device 20 includes a wireless or wired communication link 58 (CL 58) for communicating via network 102 (FIG. 1) to the main control unit (MCU 110), to communicate data and signals obtained from the sensors 22. In embodiments, if the object 10 and/or each punch or push measurement device 20 is provided with, or connected to, a CU 106, CU 106 may receive sensor data from sensors 22 and communicate such data via CL 58 to the MCU 110. Each punch or push measurement device 20 may include a switch to turn each device ON (or OFF) and enable communication with MCU 110, according to embodiments herein.

[0058] Similarly, in an embodiment, each wearable device 40 includes a wireless or wired communication link to the main control unit (MCU 110), to communicate data and signals obtained from the sensors 30. In embodiments, if the wearable device 40 is provided with, or connected to, a CU 106, CU 106 may receive sensor data from sensors 30 and communicate such data via a communication link and network 102 to the MCU 110.

[0059] In an embodiment, each punch or push measurement device 20 includes transmission technology, for example, Bluetooth®, Wi-Fi technology, or another connection for transmitting data. In an embodiment, each wearable device 40 includes transmission technology, for example, Bluetooth®, Wi-Fi technology, or another connection for transmitting data.

[0060] In embodiments, each punch or push measurement device 20 includes a battery in its housing, to provide power to the components (e.g., shown in FIG. 3) and device itself. In an embodiment, the battery may be an interchangeable battery (e.g., a single AAA battery or similar battery) or a rechargeable battery. In embodiments, each wearable device 40 includes a battery in its housing, to provide power to the components (e.g., shown in FIG. 2 and device itself. In an embodiment, the battery may be an interchangeable battery (e.g., a single AAA battery or similar battery) or a rechargeable battery. Further, each punch or push measurement device 20 and/or wearable device 40 may include a PCB and an ON/OFF switch for selectively providing power to the respective device, as well as a means of initiating wireless connection with other devices.

[0061] According to embodiments herein, the processors 106 and/or computing device 110 may include control software (such as an application or mobile app, which present information via a dashboard for displaying on a display device, e.g., output device 108). In embodiments, the control software may provide, for example, the following non-limiting and exemplary functions:

- [0062] - individual account creation
- [0063] - choice of training sequence
- [0064] - reaction time measurement (test)
- [0065] - training for specific punch types
- [0066] - arbitrary punch sequence
- [0067] - predefined sequence of punches (combo)
- [0068] - arbitrary sequence of combos
- [0069] - predefined sequence of combos

- [0070] - multiuser Remote Boxing competition over the internet
- [0071] - Real-Time (RT) data collection and visualization
- [0072] - punch data
- [0073] - combo summary data
- [0074] - training summary data
- [0075] - leader board
- [0076] - training data history/LOG
- [0077] - units preference
- [0078] - system control instructions
- [0079] - DOWNLOAD TO DEVICES (Timing, Punches, Combos, Program)
- [0080] - RESET
- [0081] - RESTART (Sensor control , settings)
- [0082] - About
- [0083] - Help
- [0084] As noted, the system 100 may be configured to implement a training routine or workout to a user or boxer, in order to improve punching force, punching speed, and accuracy, for example, Such a training routine may select from an available list given a number of punch or push measurement devices 20 to be used (e.g., one, two, three or four devices 20) and the corresponding zones 12 of the object 10. Each individual punch or push measurement device 20 must be turned ON via its switch, and paired via Bluetooth® (wirelessly) with MCU 110, to determine a device ID (or name). Each punch or push measurement device 20 may be then associated with its zone ID. That is, as previously mentioned, a user or person may be directed to power each punch or push measurement device 20 in a particular manner such that each device is properly synced and assigned its zone ID (e.g., in an anti- or counter-clockwise direction within the object 10) and thus associated with a particular punch zone (12a, 12b, etc.). All devices may be placed into their identified pockets 14 in the object 10 / PV with any indicators (e.g., LEDs) and/or output devices 108 visible to and/or positioned towards the boxer.
- [0085] For every punch or push measurement device 20 and every punch force detected via sensors 30 in the wearable device(s) 40, the below data may be collected, e.g., via CU(s) 106 and provided to MCU 110:
- [0086] - zone ID (preset)
- [0087] - angle beta (horizontal plane) β

[0088] – time t

[0089] – reaction time r

[0090] – force f

[0091] – acceleration a

[0092] – angle α (vertical direction, inclination)

[0093] – angular velocity (used for angle measurements)

[0094] – magnetometer data d (used for angle measurements)

[0095] In embodiments, more than one reaction time may be measured and calculated. For example, as previously mentioned, Initial Reaction Time (IRT) and Target-Force Reaction Time (TFRT) may be determined. In addition, other types of reaction time that may be measured (and determined) include (but is not limited to):

[0096] Acceleration target level (e.g. 3g) reaction time: after a signal is provided to the user, a reaction time to reach a particular acceleration of the glove / wearable device 40 is measured (e.g., an attack type reaction time); and

[0097] Protection reaction time: after a signal is provided to the user, a reaction time to take high guard protection position, i.e., to move the gloves / wearable devices 40 via movement of the hands and arms in a particular known defense position (e.g., in front of the face and/or body), is measured. Such a reaction time may be applicable to both boxing and other martial art sports, for example.

[0098] The zone ID and the delay time may be downloaded to all punch or push measurement devices 20 by the App / MCU 110, according to embodiments herein, and the other parameters may be measured during the punch (via wearable device 40 and/or punch measurement devices 20) and sent to the App / MCU 110 in real-time. The Force threshold values may be individually defined for each device.

[0099] Thereafter, the App / MCU 110 sends and configures individually to every measurement device 20 the delay value (e.g., relative to the common START timers 28 command) for making its LI blink for a specific time (in [ms]), such as shown in FIG. 3 for example. This delay and/or timing may also be arranged by using an “on/off” command by the App.

[00100] All device timers 28 start simultaneously when a START command is issued by the App and make their LI 55 blink when the delay time elapses. According to embodiments herein, a specific value may require blinking (i.e. visual indication) to be initiated by a device or its housing in arbitrary moment (e.g., 1000 ms, or using a random

number generator.). In embodiments, specific values for time delay and blink duration may be downloaded to each punch or push measurement device 20.

[00101] In addition, this disclosure presents a useful practical reaction time measurement, called Target-Force Reaction Time: this is reaction time to a stimulus to deliver a punch with a particular useful target force with desired effect. According to embodiments herein, the Target-Force Reaction Time can be measured as the time elapsed between the blink and the moment of punch, identified by a small target like 2 lb. force. This is close to a touch reaction time variant, for example. In some embodiments, this reaction time may be identified by device 20 above a larger given threshold, i.e. predefined target force like 50 lb.. This indicates the reaction time of the boxer to produce a required punch with force 50 lb. force.

[00102] Every punch or push measurement device 20 sends back to the App / MCU 110 all measured data (or a compressed subset of the data) for logging, real-time and statistics visualization after every punch including any and all data previously listed above (e.g., zone ID, angle beta, time t, etc.). Further, MCU 110 / the App collects data from all devices and may prepares visualizations in the form of real-time dashboards and/or a statistic table, which may be presented via output device 108. A specific dashboard may be presented, according to embodiments herein, for any different boxing training [Punch, Combo, Sequence of Combos, Full Training] regimes and/or users.

[00103] According to embodiments, all data (measured, determined, and calculated) may be archived for each user / person for progress analysis.

[00104] In embodiments, after the end of every punch combination (combo), the MCU 110 / App can set up the next combo in the sequence. In some embodiments, a pre-defined PAUSE may be arranged between each punch combination presented to the user, which may or may not require activation (e.g., via pressing an electronic button) before starting the next / queued combination.

[00105] Further, as previously described, a punch combination that is presented to the user may be as a result of, or based on, machine learning techniques employed by the MCU 110. For example, as a result of data collected by the sensors in punch or push measurement devices 20 and wearable device 40, and the calculations / determinations based on same (i.e., punch accuracy, efficiency, reaction time, and other geometries of the punches), the MCU 110 may alter the next punch combination presented to the user. In one non-limiting exemplary embodiment, for example, the next punch combination presented to the user may

be altered to target particular punch or push measurement devices 20 in zones of the object 10 where a user was less accurate or forceful with their punch force. In another non-limiting embodiment, the next punch combination presented to the user may be altered to increase the number and/or timing of punches within a length of the combination. Other changes may also be implemented to the training routine or workout.

[00106] In another, non-limiting embodiment, machine learning methods or motion sensors' data analysis (like typical accelerometer and gyroscope values and ranges for different punch types) can be used for implementing punch type recognition in software or firmware. A recognized punch type that matches the target punch type, can increase the score of an accuracy assessment when specific punch types such as but not limited to jab, US hook, European hook, and uppercut, are required to be applied to target punch measurement devices or their housing pockets in a vest. For example: An illuminated left or right-side vest pocket indicates a target left or right hook punch type. If a different punch type is recognized by the assessment software (based on sensor data from the glove), the test or the challenge is considered failed. The same rules can be applied to centrally placed device pockets in the vest, which are targets for jab, cross or uppercut punches.

[00107] In a non-limiting embodiment, an ppp / MCU 110 may display via output device 108 stats regarding a user's training routine. For example, upon completion of a punch combination or training routine, one or more of the following may be displayed via the App on the output device 108 to the user / trainer: a workout duration (e.g., in seconds), total number of punches, total number of landed punches above target force, on requested target device, total number of missed punches, precision (%), fastest punch (shortest reaction time in ms), slowest punch (ms), strongest punch (lbs.), weakest punch (lbs.), and/or total force (sum in lbs.). In some cases, additional information, such as the zone or side in which such data was collected, may also be displayed.

[00108] According to embodiments herein, system 100 may be configured such that a punch is defined by $b = (z, t, ft)$, where: z is the zone ID, t is delay after receiving START command, and ft is the force threshold.

[00109] According to embodiments herein, Effective Punch Power P_i is defined as $P = f * \cos(\alpha) * \sin(\beta)$, where f is the force, measured at every sample.

[00110] According to embodiments herein, a Combo of m punches (blows) is defined as $C = \{b_1, b_2, \dots, b_m\}$, where m is the number of punches in the combo.

[00111] According to embodiments herein, a Combo Workout W that contains n combos is defined as $W = \text{SUM}(C[j]), j=1,..n$

[00112] According to embodiments herein, a COMBO sequence of s combos is defined as $S = \{C1, C2, \dots Cs\}$

[00113] According to embodiments herein, a Drill effort D is defined as $D = \text{SUM}(W[j]), j=1,..d$

[00114] In embodiments herein, Physical force is well known as $F=ma$, where m is acting mass, and a is acceleration.

[00115] The geometry of the punch is illustrated in FIG. 4, as previously described.

[00116] According to embodiments herein, Efficiency E of a straight punch (jab or cross) delivered by the boxer, can be defined as:

$$E = \frac{F}{R} \cdot \cos(\alpha) \cdot \sin(\beta)$$

where: F is the Peak measured Force in lbs. within a predefined period, and R is measured Target-Force Reaction Time in milliseconds (time for the boxer to respond to a signal and reach a defined target force level).

$\cos(\alpha)\sin(\beta)$ can be equal to:

- max $1 \times 1 = 1$ when $\beta=90$ and $\alpha=0 \Rightarrow$ 100% efficient punch to hit the target directly; or
- min 0 when $\beta=0$ or $\beta=180$ or $\alpha=90$ or $\alpha=-90 \Rightarrow$ unreachable target point, makes $E=0$.

One or more of the processors and/or computing systems described above may be configured to determine some or all of the above information.

[00117] In some embodiments, when no punch over the force threshold is registered after the blink of a certain device within a specified timeout period, a specified big value in ms for the Reaction time may be sent to the App / MCU 110 to indicate a punch failure. In such cases, the efficiency E will be negligible, i.e. very close to zero.

[00118] Non-limiting examples of timelines for 2 punch combinations: COMBO1 and COMBO2, are shown in FIG. 5. As previously mentioned, such combinations may include providing different combinations of time blinking schedules that correspond to directions sent to a user for providing punches to particular punch measurement devices 20 as part a training regime. FIG. 5 illustrates examples of times and zones in which a blink schedule is presented.

[00119] Notes for various possible embodiments follow:

[00120] 1. Every device 20 blinks independently and collects its own data: Force, acceleration, reaction time – related events, etc.

[00121] 2. Every device 20 can be repeated in any sequence, i.e. have 2 or more delay intervals specified by the app.

[00122] 3. Every device 20 should be positioned in or with respect to object 10 such that its LED / indicator 55 is visible by the person / user doing the punches.

[00123] 4. To determine $\alpha = 0$ for a device/punch (inclination): a point in space where the punch should make contact is required; accordingly, a vertical line along the gravity direction is determined (see FIG. 4). A perpendicular to this line, starting at the point of contact in space, is the line for $\alpha = 0$ for this device / punch.

[00124] According to embodiments herein, the MCU 110 is configured to determine and/or calculate a number of measurements based on the signals and data received from the sensors 104 (i.e., sensors 22 and sensors 30) via CU(s) 106. Below are examples of measurements that may be determined by the MCU 110, and, optionally, displayed or output to the user via output device 108 and/or interface 118:

[00125] For a single punch (or push), the system and the method implemented by the disclosed system provides the following main measurements:

[00126] (1) Force measurements (including Peak force measured after impact),

[00127] (2) Linear Acceleration measured at impact,

[00128] (3) Initial Reaction Time (IRT) starting at a signal provided to the boxer (pusher) and ending at the time to achieve a minimum “touch”-level force (e.g., 0.6 lb.),

[00129] (4) Target-Force Reaction Time (TFRT): starting at a signal provided to a boxer (pusher) and ending at the time to achieve a target force (e.g., 70 lb.),

[00130] (5) Two 3D angular measurements related to the efficiency of a straight punch (jab or cross):

[00131] - angle beta (horizontal plane)

[00132] - angle alpha (vertical direction, inclination)

[00133] (6) Reaction-based Punch (Push) Speed can be calculated using a distance from glove sensor 30 to the object 10 (e.g., a punch bag), which may be calculated by a dead reckoning algorithm. Speed will be this distance divided by the Target-Force Reaction Time (Note: it is a Reaction-based Speed, because Human Perception time and Information processing time is also included in this reaction time). Dead reckoning may be used for a short period that will allow minimal drift during Kalman filtering with a 6DoF IMU. The

same speed can also be calculated more accurately by integrating the glove acceleration over time: This method can be used to measure the speed of various types of punches such as jabs, hooks, and other punch types. It can include the following main steps to be performed at the end of a short sample period of 10 ms or less:

- 1) Obtain linear accelerations from a motion sensor
- 2) Calculate Euler angles and gravity components
- 3) Adjust linear accelerations by taking into account the gravity components
- 4) Integrate accelerations on 3 axes over time: add the portions related to the elapsed sample period
- 5) Calculate and show speed in real-time, based on 3 axis accelerometer data.
- 6) Detect the punch moment and calculate the maximum speed for the punch, using the history of the total speed, based on 3 axis data.

Another method to calculate distance and speed, is using a radar or lidar sensors.

[00134] (7) Punch (Push) Accuracy related to a punch (or push) contact with the correct target place on the whole punched object 10.

[00135] (8) Rate of Force Development: Target-Force divided by the Delta Reaction Time, where Delta Reaction Time = TFRT-IRT.

[00136] (9) Efficiency E of a straight punch (jab or cross) delivered by the user / boxer, according to embodiments herein, may be defined as:

[00137] Peak force in lb.

[00138] $E = \text{-----} * \cos(\alpha) * \sin(\beta),$

[00139] Target-Force Reaction Time in ms

[00140] (Peak force in lb.) * (Accuracy in %)

[00141] (10) Activbody SPR index = -----

[00142] Target-Force Reaction Time in ms

[00143] Example for a max high index: $(300 \text{ lb.} * 100) / 100 = 300$

[00144] Example for a min low index: $(3 \text{ lb.} * 1) / 3000 = 0.001$

[00145] One or more of the processors and/or computing systems described above may be configured to determine some or all of the above information.

[00146] According to embodiments herein, the system 100 is configured to determine and/or calculate Reaction Time Measurements for Push Action. In embodiments, a Push Action is an action done, performed, or completed by a body part of a user onto a punching bag or a similar object 10, and includes N steps forward and force applied to object 10

simulating an opponent, where N may be 1, 2, ... 5. Such an example that requires such actions is American football. In embodiments, the time to make the steps is included in the two types of these force reaction time measurements: Initial (IRT) and Target(TFRT).

[00147] FIG. 6 illustrates examples of information that may be provided to a user via a display (on the user's smartphone in this example). As shown in FIG. 6, in some embodiments, statistics such as workout duration, total punches, landed punches, missed punches, precision, fastest punch, slowest punch, strongest punch, weakest punch, total force, etc., may be determined and presented to a user as described above. Note that FIG. 6 is an example only, and many other types of information may be presented in this way and/or in other ways (e.g., on other devices, etc.).

[00148] FIG. 7 illustrates a method 700 for measuring punch or push parameters. Method 700 may be performed with a system such as system 100 shown in FIG. 1-6 and/or portions thereof, and/or other systems as described herein. In some embodiments, one or more operations of method 700 are performed or controlled by a controller (such as a CU or an MCU) described above, one or more processors, and/or a computing system, as described herein, which may form and/or be included in the controller. The operations of method 700 presented below are intended to be illustrative. In some embodiments, method 700 may be accomplished with one or more additional operations not described, and/or without one or more of the operations discussed. Additionally, the order in which the operations of method 700 are illustrated in Fig. 7 and described below is not intended to be limiting.

[00149] In some embodiments, one or more operations of method 700 may be implemented in and/or controlled by one or more processing devices (e.g., a digital processor, an analog processor, a digital circuit designed to process information, an analog circuit designed to process information, a state machine, and/or other mechanisms for electronically processing information, as described herein). The one or more processing devices may include one or more devices executing some or all of the operations of method 700 in response to instructions stored electronically on an electronic storage medium. The one or more processing devices may include one or more devices configured through hardware, firmware, and/or software to be specifically designed for execution of one or more of the operations of method 700.

[00150] Method 700 comprises providing 702 one or more punch or push measurement devices in an object, with each punch or push measurement device hosting a plurality of sensors therein. For example, each punch or push measurement device may

include one or more force sensors, linear acceleration sensors, angular velocity sensors, magnetometer, timing sensors, optical (such as structured light) sensors, lidar, electro-magnetic (radar) sensors, and/or electro-static (distributed capacitance) based motion sensors, an audio sound device, a visual indicator, a voice control system, and/or a combination thereof.

[00151] Method 700 comprises sensing 704, via one or more force sensors, linear acceleration sensors, angular velocity sensors, a magnetometer, timing sensors, optical (such as structured light) sensors, lidar, electro-magnetic (radar) sensors, and/or electro-static (distributed capacitance) based motion sensors, information related to forces applied thereto, movements, timing, acceleration, etc.. The one or more force and/or other sensors are provided in the object and/or also included in one or more separate wearable devices. A wearable device may comprise one or more force sensors, one or more motion sensors embedded therein – e.g., comprising an accelerometer, gyroscope and/or a magnetometer, and/or other components.

[00152] Method 700 comprises generating 706 output signals conveying the information related to forces applied to the one or more force sensors, and/or other information from one or more of the other sensors. In some embodiments, as an example, the wearable device comprises training gloves, half gloves, or boxing gloves, each providing punch or push measurements individually determined based on the output signals.

[00153] Method 700 comprises collecting and transferring 708 data via at least one hardware control unit associated with the object and/or the wearable device to a main control unit. For example, method 700 may comprising sensing (operation 704), generating (operation 706) output signals from, and forwarding (operation 708) data from the one or more punch measurement devices (and any or all of the associated sensors described above) to the main control unit.

[00154] Method 700 comprises determining 710 measurements and calculations associated with: punch speed, punch accuracy (correct target devices punched or pushed), acceleration applied to the wearable devices, and the forces applied to the one or more force sensors, by using the main control unit. In some embodiments, punches or pushes: are contactless; comprise methods to measure acceleration reaction time and protection reaction time included in a contest; comprise a boxing and/or martial arts contest based fully on measurements, without any physical contact; and/or provide information for an assessment stats panel such that a trainer can track and check all trainee results in a single place

comprising a computer monitor or a computer file. For example, in some embodiments this operation of method 700 comprises aggregating data into a leader board, for example, and determining a winner in a contest between two or more competitors who apply punches or pushes in parallel in real-time, or in a sequence, to one or more dedicated punch or push measurement devices. In this example, each competitor uses wearable devices equipped with sensors, such that parameters related to applied force, reaction time, accuracy, acceleration, and speed, are tracked and compared to determine a better performer or a winner, without physical contact between performers or contenders in the contest. The contest can be held at a same physical location, or at two or more remote locations, where punch or push data is transferred over the internet, then collected and processed including comparisons, by a central computer server.

[00155] In some embodiments, determining 710 comprises use of wearable devices equipped with motion sensors (e.g., as described herein) together with an algorithm for calculating real-time and maximum speed of a punch, based on integration of wearable device acceleration over time. The algorithm is configured to run in a local wearable device or in a separate connected control unit comprising an additional processor programmed with machine instructions.

[00156] In some embodiments, determining 710 comprises calculating Target Force Reaction Time, in which a stimulus is provided to a user (e.g., a boxer), and a reaction time is calculated from a moment of providing the stimulus, to a moment when a target force is reached by a punch, push, or a similar action done by the user. Method 700 may be configured such that an optional challenge or a test for Target Force Reaction Time passes if the force is reached within a specified interval of time.

[00157] In some embodiments, determining 710 comprises calculating Target Acceleration Reaction Time, in which a stimulus is provided to a user (e.g., a boxer), and a reaction time is calculated from a moment of providing the stimulus, to a moment when a target acceleration is reached by a punch or push. Method 700 may be configured such that an optional challenge or a test for Target Acceleration Reaction Time passes if the acceleration is reached within a specified interval of time. The punch or push may be done by a body part with an attached measurement sensor, or a glove with an embedded measurement device, hitting/punching a physical target object, for example. Also, a contactless method may be used comprising shadow boxing, for example, when a wearable

device is handheld or attached to a human body part, and movement in air creates motion comprising measured acceleration or rotation.

[00158] In some embodiments, determining 710 comprises calculating Protection Reaction Time, in which a stimulus is provided to a user, and a reaction time is calculated from a moment of providing the stimulus, to a moment when a target protective guard position is reached by the user. Method 700 may be configured such that an optional challenge or a test for Protection Reaction Time passes if the protective guard position is reached within a specified interval of time. The protective guard position may be detected by sensor(s) and/or a control unit in a wearable device embedded in a glove, for example, or detected by a secured device held in hand, or detected by sensors attached to a human body part, among other possibilities described herein.

[00159] In some embodiments, determining 710 comprises determining an Efficiency E of a straight punch comprising a jab or cross delivered by a boxer. A separate compound estimate comprising an index for Strength, Precision, and Reaction time (SPR), may be defined as an SPR index.

[00160] Method 700 comprises outputting and displaying 712 information, measurements, and calculations determined by said main control unit to a user. The display can include the dashboard or leaderboard in the previous example, indications of correct punches or pushes, a sequence for a user to follow, one or more of the calculated parameters described above (e.g., Target Force Reaction Time, Target Acceleration Reaction Time, Protection Reaction Time, Efficacy, SPR, etc.), and/or other information.

[00161] In some embodiments, method 700 may be used for training. By way of several examples, as part of method 700, the or more punch measurement devices may each comprise an audio sound device and/or visual indicator, and/or may be complemented by additional such indicators. Method 700 may comprise issuing an audible sound and/or indicator via said one or more punch measurement devices, or may comprise providing the audible sound and/or indicator via a separate voice control system. In some embodiments, a visual indicator comprising one or more LEDs may be provided. Method 700 may comprise lighting the LED(s) as a stimulus for another punch, kick, push, or protection action done by the user; and/or a variant of this method, in which a stimulated requested punch or push is applied onto an object such as one or more display screen(s). For example, flat, bent, or other types of display screens can be used as a punching or pushing area and show an opponent as a target, and the force of a delivered punch, kick, or push to this screen can be measured by

force sensors in/on the screen. The accuracy of the punch can also be measured by using a set of position sensors in/on the screen.

[00162] In some embodiments, method 700 comprises performing punch type recognition for a wearable device that sends sensor data at a minimum 100 Hz rate, to a main control unit (MCU). The punch type recognition may be based on machine learning or on an algorithm using data from motion sensors comprising an accelerometer, gyroscope, a magnetometer, and/or other sensors. A recognized punch type can be taken into account in an exercise, pass/fail test or challenge assessment when specific punch types including but not limited to jab, American hook, European hook, and uppercut, are required to be applied to multiple target zones or objects, for example.

[00163] In some embodiments, as part of method 700, two wearable devices designated “left” and “right”, known to a main control unit, are used such that individual device punch forces and sensor data are tracked in time and reports are produced to compare left and right forces, punch speeds, punch target accuracy, and/or punch type accuracy, for example. The two wearable devices may have embedded sensors configured to generate information used to calculate or provide periodic sensor data to the main control unit to calculate current and/or maximum force, total summed up force, motion-related parameters comprising speed and/or acceleration in a free mode without indicated target places/points to the user. The user can decide when and how to punch or push a physical object, or even simply punch in air.

[00164] In some embodiments, as part of method 700, visual indicators are used to indicate a specific target zone and/or specific required punch type comprising a straight punch, left hook punch, right hook punch, and/or uppercut punch. An actual punched or pushed zone and/or punch type may be detected using sensors, and compared to an indicated target zone and/or expected punch type. A statistical report may be produced to track punch accuracy related to a target zone and/or expected punch type, for example. Target zones and/or punch types may be indicated in a sequence combination in time, by a main control unit, where the sequence has different zones to punch, random or predefined periods between indicated targets, and the sequence is programmable and adjustable.

[00165] In some embodiments, as part of method 700, a main control unit comprising a computer or a mobile device measures protection reaction time by wirelessly receiving motion data from a wearable device and a trainer’s mitt. For example, a trainer may make a recognizable mitt gesture comprising pushing the mitt horizontally towards the user to

instruct the user to take the protective guard position. The Protection Reaction Time may be measured from the recognizable mitt gesture to when the protective guard position is taken by the glove, secured device, or as indicated by the sensors attached to the human body part.

[00166] Various embodiments of the present systems and methods are disclosed in the subsequent list of numbered clauses, which may be combined in any combination.

1. A system comprising: an object having a plurality of punch zones; one or more punch or push measurement devices configured to be provided in the plurality of zones of the object, each punch or push measurement device hosting a plurality of sensors therein; one or more force sensors configured to generate output signals conveying information related to forces applied to the one or more punch or push measurement devices, said one or more force sensors being provided in a wearable device configured to be worn by a user; at least one hardware control unit associated with the object and/or the wearable device, the at least one hardware control unit comprising software for data collection and configured for data transfer; a main control unit connected to the at least one hardware control unit, the main control unit configured to receive data from one or more of the at least one hardware control unit, each of the one or more punch or push measurement devices, and/or the one or more force sensors, said main control unit configured to utilize the received data to determine measurements and calculations associated with the forces applied to the one or more punch or push measurement devices; and an interface configured to output and display information, measurements, and calculations determined by said main control unit to the user.
2. The system of clause 1, wherein the object is selected from the group consisting of: a boxing bag, a boxing surface, and a flat or oval/bent display screen.
3. The system of any of the previous clauses, wherein the object is a wearable item, said wearable item being one of the following: a vest, a shirt, boxing mitts or pads, and pants.
4. The system of any of the previous clauses, wherein the one or more punch or push measurement devices are attached to or inserted into the object.
5. The system of any of the previous clauses, wherein the one or more punch or push measurement devices are embedded within the object.
6. The system of any of the previous clauses, wherein the plurality of sensors of each punch or push measurement device include force sensors, linear acceleration sensors, angular velocity sensors, magnetometer, and timing sensors, and/or a combination thereof.
7. The system of any of the previous clauses, wherein a separate wearable device further comprises one or more force and/or motion sensors embedded therein.

8. The system of any of the previous clauses, wherein the wearable device comprises training gloves, half gloves, or boxing gloves.
9. The system of any of the previous clauses, wherein the one or more punch or push measurement devices each comprise an audio sound device and/or visual indicator.
10. The system of any of the previous clauses, wherein the visual indicator comprises a light emitting diode (LED) or a screen, where an LED variant includes a plurality of LEDs, connected separately or embedded in stripes, borders, arrays or planes, placed over and/or into a punching bag or a humanoid mannequin, a torso or a part of a torso, to indicate target areas to be punched.
11. The system of any of the previous clauses, wherein an indication of punching or pushing a correct or incorrect target by the user, is made by the system using one or more of: - a change of an LED color, - a change of a current blinking or flashing LED pattern, - a change of LED light intensity level, - turning off an LED, and/or - a separate type of audio signal, voice, or melody.
12. The system of any of the previous clauses, wherein the main control unit is a local or remote computer, or a mobile device.
13. A method for measuring punch or push parameters, the method comprising: providing one or more punch or push measurement devices in an object, each punch or push measurement device hosting a plurality of sensors therein; sensing, via one or more force sensors, information related to forces applied thereto, said one or more force sensors being provided in the object and/or also included in one or more separate wearable devices; generating output signals conveying the information related to forces applied to the one or more force sensors; collecting and transferring data via at least one hardware control unit associated with the object and/or the wearable device to a main control unit; determining measurements and calculations associated with: punch speed, punch accuracy (correct target devices punched or pushed), acceleration applied to the wearable devices, and the forces applied to the one or more force sensors, by using the main control unit; and outputting and displaying information, measurements, and calculations determined by said main control unit to a user.
14. The method of clause 13, wherein each punch or push measurement device includes one or more force sensors, linear acceleration sensors, angular velocity sensors, magnetometer, timing sensors, optical (such as structured light) sensors, lidar, electro-magnetic (radar) sensors, and/or electro-static (distributed capacitance) based motion sensors, and/or a

combination thereof, and wherein the method further comprises sensing and forwarding data from said one or more punch measurement devices to the main control unit.

15. The method of any of the previous clauses, wherein the wearable device further comprises one or more force sensors, one or more motion sensors embedded therein - comprising an accelerometer, gyroscope and/or a magnetometer, and wherein the method further comprises sensing and forwarding force and motion data, including acceleration, to the main control unit, and determining punch type or geometry, including punching angles, relating to punch forces, using motion sensors, control units, and the main control unit.

16. The method of any of the previous clauses, further comprising comparing data in a leader board and determining a winner in a contest between two or more competitors who apply punches or pushes in parallel in real-time, or in a sequence, to one or more dedicated punch or push measurement devices, each competitor using wearable devices equipped with sensors, such that parameters related to applied force, reaction time, accuracy, acceleration, and speed, are tracked and compared to determine a better performer or a winner, without physical contact between performers or contenders in the contest.

17. The method of any of the previous clauses, wherein the punches or pushes: are contactless; comprise methods to measure acceleration reaction time and protection reaction time included in the contest; comprise a boxing and/or martial arts contest based fully on measurements, without any physical contact; and/or provide information for an assessment stats panel such that a trainer can track and check all trainee results in a single place comprising a computer monitor or a computer file.

18. The method of any of the previous clauses, wherein the contest can be held at a same physical location, or at two or more remote locations, where punch or push data is transferred over the internet, then collected and processed including comparisons, by a central computer server.

19. The method of any of the previous clauses, wherein the wearable device comprises training gloves, half gloves, or boxing gloves, each providing punch or push measurements individually.

20. The method of any of the previous clauses, wherein the one or more punch measurement devices each comprise an audio sound device and/or visual indicator or are complemented by additional such indicators, and wherein the method further comprises issuing an audible sound and/or indicator via said one or more punch measurement devices, or the method comprises providing the audible sound and/or indicator via a separate voice control system.

21. The method of any of the previous clauses, wherein the visual indicator comprises an LED(s), and wherein the method further comprises lighting the LED(s) that can be a stimulus for another punch, kick, push, or protection action done by the user; and/or a variant of this method, in which a stimulated requested punch or push is applied onto an object such as one or more display screen(s), wherein a flat, bent, or other types of display screen can be used as a punching or pushing area and show an opponent as a target, and the force of a delivered punch, kick, or push to this screen can be measured by force sensors in/on the screen, and wherein the accuracy of the punch can also be measured by using a set of position sensors in/on the screen.

22. The method of any of the previous clauses, where punch type recognition is done for a wearable device that sends sensor data at a minimum 100 Hz rate, to a main control unit (MCU), wherein the punch type recognition is based on machine learning or on an algorithm using data from motion sensors comprising an accelerometer, gyroscope, and/or a magnetometer, and wherein a recognized punch type can be taken into account in an exercise, pass/fail test or challenge assessment when specific punch types including but not limited to jab, American hook, European hook, and uppercut, are required to be applied to multiple target zones or objects.

23. The method of any of the previous clauses, wherein two wearable devices designated "left" and "right", known to a main control unit, are used such that individual device punch forces and sensor data are tracked in time and reports are produced to compare left and right forces, punch speeds, punch target accuracy, and/or punch type accuracy, wherein the two wearable devices have embedded sensors configured to generate information used to calculate or provide periodic sensor data to the main control unit to calculate current and/or maximum force, total summed up force, motion-related parameters comprising speed and/or acceleration in a free mode without indicated target places/points to the user, wherein the user decides when and how to punch or push a physical object, or the user punches in air.

24. The method of any of the previous clauses, wherein visual indicators are used to indicate a specific target zone and/or specific required punch type comprising a straight punch, left hook punch, right hook punch, and/or uppercut punch; wherein an actual punched or pushed zone and/or punch type are detected using sensors and are compared to an indicated target zone and/or expected punch type, and a statistical report is produced to track punch accuracy related to a target zone and/or expected punch type; and wherein target zones and/or punch types are indicated in a sequence combination in time, by a main control unit, where the

sequence has different zones to punch, random or predefined periods between indicated targets, and the sequence is programmable and adjustable.

25. A method of any of the previous clauses, further comprising calculating Target Force Reaction Time, in which a stimulus is provided to a user (e.g., a boxer), and a reaction time is calculated from a moment of providing the stimulus, to a moment when a target force is reached by a punch, push, or a similar action done by the user, wherein an optional challenge or a test for Target Force Reaction Time passes if the force is reached within a specified interval of time.

26. A method of any of the previous clauses, further comprising calculating Target Acceleration Reaction Time, in which a stimulus is provided to a user (e.g., a boxer), and a reaction time is calculated from a moment of providing the stimulus, to a moment when a target acceleration is reached by a punch or push, wherein an optional challenge or a test for Target Acceleration Reaction Time passes if the acceleration is reached within a specified interval of time; and wherein the punch or push is done by a body part with an attached measurement sensor, or a glove with an embedded measurement device, hitting/punching a physical target object, or a contactless method is used comprising shadow boxing when a wearable device is handheld or attached to a human body part, and movement in air creates motion comprising measured acceleration or rotation.

27. A method of any of the previous clauses, further comprising calculating Protection Reaction Time, in which a stimulus is provided to a user, and a reaction time is calculated from a moment of providing the stimulus, to a moment when a target protective guard position is reached by the user, wherein an optional challenge or a test for Protection Reaction Time passes if the protective guard position is reached within a specified interval of time; and wherein the protective guard position is detected by sensor(s) and/or a control unit in a wearable device embedded in a glove, or detected by a secured device held in hand, or detected by sensors attached to a human body part.

28. The method of any of the previous clauses, wherein the sensors send motion data to a main control unit (MCU), that detects the protective guard position; a main control unit comprising a computer or a mobile device measures protection reaction time by wirelessly receiving motion data from a wearable device and a trainer's mitt, wherein the trainer makes a recognizable mitt gesture comprising pushing the mitt horizontally towards the user to instruct the user to take the protective guard position; and the Protection Reaction Time is

measured from the recognizable mitt gesture to when the protective guard position is taken by the glove, secured device, or as indicated by the sensors attached to the human body part.

29. The method of any of the previous clauses, wherein an Efficiency E of a straight punch comprising a jab or cross delivered by a boxer, and a separate compound estimate comprising an index for Strength, Precision, and Reaction time (SPR), is defined as an SPR index.

30. A method of any of the previous clauses, further comprising use of wearable devices equipped with motion sensors together with an algorithm for calculating real-time and maximum speed of a punch, based on integration of wearable device acceleration over time, further applying adjustment to the linear accelerations by considering the gravity components, wherein the algorithm is configured to run in a local wearable device or in a separate connected control unit comprising an additional processor programmed with machine instructions.

[00167] While the principles of the disclosure have been made clear in the illustrative embodiments set forth above, it will be apparent to those skilled in the art that various modifications may be made to the structure, arrangement, proportion, elements, materials, and components used in the practice of the disclosure.

[00168] It will thus be seen that the features of this disclosure have been fully and effectively accomplished. It will be realized, however, that the foregoing preferred specific embodiments have been shown and described for the purpose of illustrating the functional and structural principles of this disclosure and are subject to change without departure from such principles. Therefore, this disclosure includes all modifications encompassed within the spirit and scope of the following claims.

WHAT IS CLAIMED IS:

1. A system comprising:
 - an object having a plurality of punch zones;
 - one or more punch or push measurement devices configured to be provided in the plurality of zones of the object, each punch or push measurement device hosting a plurality of sensors therein;
 - one or more force sensors configured to generate output signals conveying information related to forces applied to the one or more punch or push measurement devices, said one or more force sensors being provided in a wearable device configured to be worn by a user;
 - at least one hardware control unit associated with the object and/or the wearable device, the at least one hardware control unit comprising software for data collection and configured for data transfer;
 - a main control unit connected to the at least one hardware control unit, the main control unit configured to receive data from one or more of the at least one hardware control unit, each of the one or more punch or push measurement devices, and/or the one or more force sensors, said main control unit configured to utilize the received data to determine measurements and calculations associated with the forces applied to the one or more punch or push measurement devices; and
 - an interface configured to output and display information, measurements, and calculations determined by said main control unit to the user.
2. The system according to claim 1, wherein the object is selected from the group consisting of: a boxing bag, a boxing surface, and a flat or oval/bent display screen.

3. The system according to claim 1, wherein the object is a wearable item, said wearable item being one of the following: a vest, a shirt, boxing mitts or pads, and pants.
4. The system according to claim 1, wherein the one or more punch or push measurement devices are attached to or inserted into the object.
5. The system according to claim 1, wherein the one or more punch or push measurement devices are embedded within the object.
6. The system according to claim 1, wherein the plurality of sensors of each punch or push measurement device include force sensors, linear acceleration sensors, angular velocity sensors, magnetometer, and timing sensors, and/or a combination thereof.
7. The system according to claim 1, wherein a separate wearable device further comprises one or more force and/or motion sensors embedded therein.
8. The system according to claim 1, wherein the wearable device comprises training gloves, half gloves, or boxing gloves.
9. The system according to claim 1, wherein the one or more punch or push measurement devices each comprise an audio sound device and/or visual indicator.

10. The system according to claim 9, wherein the visual indicator comprises a light emitting diode (LED) or a screen, where an LED variant includes a plurality of LEDs, connected separately or embedded in stripes, borders, arrays or planes, placed over and/or into a punching bag or a humanoid mannequin, a torso or a part of a torso, to indicate target areas to be punched.
11. The system according to claim 10, wherein an indication of punching or pushing a correct or incorrect target by the user, is made by the system using one or more of:
- a change of an LED color,
 - a change of a current blinking or flashing LED pattern,
 - a change of LED light intensity level,
 - turning off an LED, and/or
 - a separate type of audio signal, voice, or melody.
12. The system according to claim 10, wherein the main control unit is a local or remote computer, or a mobile device.
13. A method for measuring punch or push parameters, the method comprising:
- providing one or more punch or push measurement devices in an object, each punch or push measurement device hosting a plurality of sensors therein;
 - sensing, via one or more force sensors, information related to forces applied thereto, said one or more force sensors being provided in the object and/or also included in one or more separate wearable devices;
 - generating output signals conveying the information related to forces applied to the one or more force sensors;

collecting and transferring data via at least one hardware control unit associated with the object and/or the wearable device to a main control unit;

determining measurements and calculations associated with: punch speed, punch accuracy (correct target devices punched or pushed), acceleration applied to the wearable devices, and the forces applied to the one or more force sensors, by using the main control unit; and

outputting and displaying information, measurements, and calculations determined by said main control unit to a user.

14. The method according to claim 13, wherein each punch or push measurement device includes one or more force sensors, linear acceleration sensors, angular velocity sensors, magnetometer, timing sensors, optical (such as structured light) sensors, lidar, electro-magnetic (radar) sensors, and/or electro-static (distributed capacitance) based motion sensors, and/or a combination thereof, and wherein the method further comprises sensing and forwarding data from said one or more punch measurement devices to the main control unit.

15. The method according to claim 14, wherein the wearable device further comprises one or more force sensors, one or more motion sensors embedded therein - comprising an accelerometer, gyroscope and/or a magnetometer, and wherein the method further comprises sensing and forwarding force and motion data, including acceleration, to the main control unit, and determining punch type or geometry, including punching angles, relating to punch forces, using motion sensors, control units, and the main control unit.

16. The method according to claim 15, further comprising comparing data in a leader board and determining a winner in a contest between two or more competitors who apply punches or pushes in parallel in real-time, or in a sequence, to one or more dedicated punch or push measurement devices, each competitor using wearable devices equipped with sensors, such that parameters related to applied force, reaction time, accuracy, acceleration, and speed, are tracked and compared to determine a better performer or a winner, without physical contact between performers or contenders in the contest.

17. The method of claim 16, wherein the punches or pushes:
are contactless;
comprise methods to measure acceleration reaction time and protection reaction time included in the contest;
comprise a boxing and/or martial arts contest based fully on measurements, without any physical contact; and/or
provide information for an assessment stats panel such that a trainer can track and check all trainee results in a single place comprising a computer monitor or a computer file.

18. The method of claim 17, wherein the contest can be held at a same physical location, or at two or more remote locations, where punch or push data is transferred over the internet, then collected and processed including comparisons, by a central computer server.

19. The method according to claim 13, wherein the wearable device comprises training gloves, half gloves, or boxing gloves, each providing punch or push measurements individually.

20. The method according to claim 13, wherein the one or more punch measurement devices each comprise an audio sound device and/or visual indicator or are complemented by additional such indicators, and wherein the method further comprises issuing an audible sound and/or indicator via said one or more punch measurement devices, or the method comprises providing the audible sound and/or indicator via a separate voice control system.

21. The method according to claim 20, wherein the visual indicator comprises an LED(s), and wherein the method further comprises lighting the LED(s) that can be a stimulus for another punch, kick, push, or protection action done by the user; and/or a variant of this method, in which a stimulated requested punch or push is applied onto an object such as one or more display screen(s), wherein a flat, bent, or other types of display screen can be used as a punching or pushing area and show an opponent as a target, and the force of a delivered punch, kick, or push to this screen can be measured by force sensors in/on the screen, and wherein the accuracy of the punch can also be measured by using a set of position sensors in/on the screen.

22. The method according to claim 13, where punch type recognition is done for a wearable device that sends sensor data at a minimum 100 Hz rate, to a main control unit (MCU), wherein the punch type recognition is based on machine learning or on an algorithm using data from motion sensors comprising an accelerometer, gyroscope, and/or a magnetometer, and wherein a recognized punch type can be taken into account in an exercise, pass/fail test or challenge assessment when specific punch types including but not limited to jab, American hook, European hook, and uppercut, are required to be applied to multiple target zones or objects.

23. The method according to claim 13, wherein two wearable devices designated “left” and “right”, known to a main control unit, are used such that individual device punch forces and sensor data are tracked in time and reports are produced to compare left and right forces, punch speeds, punch target accuracy, and/or punch type accuracy, wherein the two wearable devices have embedded sensors configured to generate information used to calculate or provide periodic sensor data to the main control unit to calculate current and/or maximum force, total summed up force, motion-related parameters comprising speed and/or acceleration in a free mode without indicated target places/points to the user, wherein the user decides when and how to punch or push a physical object, or the user punches in air.

24. The method according to claim 13, wherein visual indicators are used to indicate a specific target zone and/or specific required punch type comprising a straight punch, left hook punch, right hook punch, and/or uppercut punch; wherein an actual punched or pushed zone and/or punch type are detected using sensors and are compared to an indicated target zone and/or expected punch type, and a statistical report is produced to track punch accuracy related to a target zone and/or expected punch type; and wherein target zones and/or punch types are indicated in a sequence combination in time, by a main control unit, where the sequence has different zones to punch, random or predefined periods between indicated targets, and the sequence is programmable and adjustable.

25. A method of calculating Target Force Reaction Time, in which a stimulus is provided to a user (e.g., a boxer), and a reaction time is calculated from a moment of providing the stimulus, to a moment when a target force is reached by a punch, push, or a similar action done by the user,

wherein an optional challenge or a test for Target Force Reaction Time passes if the force is reached within a specified interval of time.

26. A method of calculating Target Acceleration Reaction Time, in which a stimulus is provided to a user (e.g., a boxer), and a reaction time is calculated from a moment of providing the stimulus, to a moment when a target acceleration is reached by a punch or push, wherein an optional challenge or a test for Target Acceleration Reaction Time passes if the acceleration is reached within a specified interval of time; and

wherein the punch or push is done by a body part with an attached measurement sensor, or a glove with an embedded measurement device, hitting/punching a physical target object, or a contactless method is used comprising shadow boxing when a wearable device is handheld or attached to a human body part, and movement in air creates motion comprising measured acceleration or rotation.

27. A method of calculating Protection Reaction Time, in which a stimulus is provided to a user, and a reaction time is calculated from a moment of providing the stimulus, to a moment when a target protective guard position is reached by the user, wherein an optional challenge or a test for Protection Reaction Time passes if the protective guard position is reached within a specified interval of time; and

wherein the protective guard position is detected by sensor(s) and/or a control unit in a wearable device embedded in a glove, or detected by a secured device held in hand, or detected by sensors attached to a human body part.

28. The method of claim 27, wherein the sensors send motion data to a main control unit (MCU), that detects the protective guard position; a main control unit comprising a computer or a mobile device measures protection reaction time by wirelessly receiving motion data from a wearable device and a trainer's mitt, wherein the trainer makes a recognizable mitt gesture comprising pushing the mitt horizontally towards the user to instruct the user to take the protective guard position; and the Protection Reaction Time is measured from the recognizable mitt gesture to when the protective guard position is taken by the glove, secured device, or as indicated by the sensors attached to the human body part.

29. The method of any of the previous claims, wherein an Efficiency E of a straight punch comprising a jab or cross delivered by a boxer, and a separate compound estimate comprising an index for Strength, Precision, and Reaction time (SPR), is defined as an SPR index.

30. A method comprising:

use of wearable devices equipped with motion sensors together with an algorithm for calculating real-time and maximum speed of a punch, based on integration of wearable device acceleration over time, further applying adjustment to the linear accelerations by considering the gravity components,

wherein the algorithm is configured to run in a local wearable device or in a separate connected control unit comprising an additional processor programmed with machine instructions.