SIGNATURE-BASED TRICK DETERMINATION SYSTEMS AND METHODS FOR SKATEBOARDING AND OTHER ACTIVITIES OF MOTION

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ABSTRACT

The invention provides improved devices, systems and methods for skateboarding (and other sporting activities) that monitor motion of a skateboard to identify tricks performed on it by a user. A system according to one aspect of the invention includes (i) a sensing device that is attached (or otherwise coupled) to the skateboard and that measures a physical characteristic of it, and (ii) a data processor that identifies the feat or trick (or other action) performed by or on the skateboard based, at least in part, on correspondence between physical characteristics of motion and/or of the environment measured by the sensing device(s) and a unique signature associated with each of one or more possible tricks.
Figure 3
<table>
<thead>
<tr>
<th>$\Theta_1(t_1)$</th>
<th>$\Theta_2(t_2)$</th>
<th>$\Theta_3(t_3)$</th>
<th>Trick</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1 \pm \sigma_x$</td>
<td>$1 \pm \sigma_y$</td>
<td>$1 \pm \sigma_z$</td>
<td>$A$</td>
</tr>
<tr>
<td>$1 \pm \sigma_x$</td>
<td>$2 \pm \sigma_y$</td>
<td>$1 \pm \sigma_z$</td>
<td>$B$</td>
</tr>
<tr>
<td>$1 \pm \sigma_x$</td>
<td>$3 \pm \sigma_y$</td>
<td>$2 \pm \sigma_z$</td>
<td>$C$</td>
</tr>
<tr>
<td>$1 \pm \sigma_x$</td>
<td>$1 \pm \sigma_y$</td>
<td>$2 \pm \sigma_z$</td>
<td>$D$</td>
</tr>
<tr>
<td>$3 \pm \sigma_x$</td>
<td>$3 \pm \sigma_y$</td>
<td>$3 \pm \sigma_z$</td>
<td>$n$</td>
</tr>
</tbody>
</table>

*Figure 4*
SIGNATURE-BASED TRICK DETERMINATION SYSTEMS AND METHODS FOR SKATEBOARDING AND OTHER ACTIVITIES OF MOTION

REFERENCE TO RELATED APPLICATIONS


The teachings of all of the foregoing applications and publications are incorporated by reference herein.


BACKGROUND OF THE INVENTION

The invention relates to improved systems and methods for skateboarding and other activities of motion—referred to, here, for sake of simplicity and without loss of generality as “sports,” “sporting activities,” and the like (regardless of whether such activities are so known in conventional parlance) and practitioners of which are referred to, here, as “sports enthusiasts,” and the like. The invention has application in facilitating training of, competition and/or among and likeminded enthusiasts.

Sports enthusiasts like to learn and perform feats. Skateboarders, for example, practice tricks over and over, in order to learn new ones and to perfect old ones. To gauge their progress, skateboarders rely on “feel,” guesswork or, better usually, the opinions of others.

Regardless, skateboarders—like other sports enthusiasts—are eager to share their progress and are always in search of new venues to do so. They may train or show their tricks in skateparks but, more often, they do so on sidewalks, in driveways, playgrounds, and other spaces that have not been designated for skateboarding. Unfortunately, they can typically only display their feats to fellow enthusiasts who are in the same locale at the same time. For example, a skateboarder who has perfected a multiple varial heel flip, is usually limited to proving his/her prowess to friends at the local park. One of them might text or “tweet” news of the feat to others, but that is likely to be dismissed as unbelievable, particularly, if the feat is extraordinary. Some of that disbelief might be dispelled by posting of a video of the feat, but even that may be subject to skepticism.

An object of the invention is to provide improved devices, systems and methods for skateboarding or other activities of motion (here, again, “sporting activities”).

A related object is to provide such improved devices, systems and methods as can be used to publicize feats of skateboarders, other sports enthusiasts and others.

A further related object of the invention is to provide improved such devices, systems and methods as can be used to facilitate interaction and/or competition among remotely disposed skateboarders, other social sports enthusiasts and others.

SUMMARY OF THE INVENTION

The foregoing are among the objects attained by the invention, which provides in some aspects improved devices, systems and methods for skateboarding (and other sporting activities) that monitor motion of a skateboard to identify tricks (feats) performed with, by or on it by a user.

A system according to one aspect of the invention includes (i) a sensing device that is attached (or otherwise coupled) to the skateboard and that measures a physical characteristic of it, and (ii) a data processor that identifies the feat or trick (or other action) performed by or on the skateboard based, at least in part, on correspondence between physical characteristics of motion and/or of the skateboard’s environment measured by the sensing device(s) and a signature associated with each of one or more possible tricks.

Further aspects of the invention provide a system, e.g., as described above, in which the sensing device—which may be coupled to the operator and particularly, for example, his/her shoes, etc., instead or in addition to being coupled to the skateboard—is gyroscopic and/or otherwise measures rotation of the skateboard and/or its operator. This can include, for example, gyroscopic sensors that measure such rotation, preferably along at least two—and, still more preferably, along at least three—of X-, y- and z-axes.
According to other aspects of the invention, other sensors suitable for detecting rotational and/or other physical characteristics of the skateboard (and/or operator) are used instead or in addition to gyroscopic sensors. These include, by way of non-limiting example, accelerometers, magnetometers, global positioning sensors, strain sensors, or other sensor(s) capable of indicating speed, acceleration, jerk, yaw, pitch, roll, or other physical characteristics of the skateboard, its user and/or the its environment.

Further aspects of the invention provide a system, e.g., as described above, in which the data processor is coupled to the skateboard and/or operator, for example, in the form of an add-on or integral module (e.g., in the case of the skateboard) or a clip-on, wearable, pocketable, or carry-along (e.g., in the case of a skater).

Still further related aspects of the invention provide a system, e.g., as described above, in which the data processor is disposed remotely from the skateboard, yet, coupled for communications with it (and, more particularly, for example, the sensing devices). Such a “remote” data processor can be a dedicated device or it can be part a multifunction device, e.g., as in the case of a data processor that is embedded in a cell phone, personal digital assistant, or other mobile device (collectively, “mobile device”), that performs other functions, e.g., in addition to identifying tricks (or other actions) by the skateboard and/or operator.

Further aspects of the invention provide a system, e.g., as described above, in which the sensing device communicates with such a remote data processor wirelessly, e.g., via Bluetooth, WiFi, cellular, infrared or other wireless or wired transmission medium, or otherwise. The data processor can optionally log and/or display measurements received from the sensor(s), e.g., in addition tricks identified by it based on those measurements. An advantage of such logging is, for example, that it makes possible validating what tricks and other actions an operator performed on the skateboard (or other object).

Yet still other aspects of the invention provide a system, e.g., as described above, that includes two (or more) data processors, e.g., one that is coupled to the skateboard and/or operator, and one that is disposed remotely. The two (or more) data processors can be coupled for communications via wire and/or wirelessly. They may, moreover, share and/or divide up one or more of the tasks attributed to the “data processor” or “server” in this summary and elsewhere herein. Thus, for example, according to one such aspect of the invention, a data processor that is coupled to the skateboard performs trick identifications based on measurements made by the sensing device and routes those identifications to the remote digital data processor, along with underlying sensor readings, for further processing by it.

Further aspects of the invention provide a system, e.g., as described above, in which the data processor includes and/or is coupled to a table (or other store) that enumerates known tricks (or other actions) and corresponding signatures, and in which the data processor compares measurements received from the sensor(s) against that table (or store) to identify tricks (or other actions) performed by the operator.

In other aspects, the invention provides a system as described above in which the sensing device is attached or otherwise coupled to a surfboard, rollerblade boot, ski, ski boot, surfboard or other object (and/or the operator thereof) in lieu of a skateboard (and/or operator thereof).

Related aspects of the invention provide a system, for example, as described above, in which the data processor—in addition to or instead of logging and/or displaying identified tricks and/or the measured characteristics—transmits them to a server digital data processor (“server”), for example, via circuitry and/or other logic provided in the mobile device of which the data processor forms a part and/or via a modem, network interface card or other circuitry, e.g., in instances where the data processor is a stand-alone device, or otherwise. Such transmission can be via Bluetooth, WiFi, cellular, infrared or other wireless or wired transmission medium, or otherwise.

Related aspects of the invention provide a system, e.g., as described above, wherein the data processor transmits the identified tricks and/or measured characteristics to the server, e.g., along with still images, video images, location and/or other information associated with the trick, measurements, skateboard, its environment, the user or otherwise. This associated information can be generated by the data processor, a mobile (or other) device of which it forms a part, or otherwise. The location information may be, for example, GPS data and/or it may be identifying information, e.g., phone number, ESN, serial number, or so forth.

Related aspects of the invention provide a system, for example, as described above, in which the server logs the identified tricks and/or measured characteristics, along with still/video images, location information and/or other information, and makes them available for access by the aforementioned mobile device and/or by other data processing apparatus, such as, mobile devices, data processors, portable computers, desktop computers, and so forth, of other enthusiasts—including other users (or “operators”) of skateboards, surfboards, rollerblade boots, or other objects (and/or the operators thereof).

Still further related aspects of the invention provide a system, for example, as described above, in which the server makes the identified tricks and/or measured characteristics, still/video images, location information and/or other information of the first aforesaid operator available for access via an addressable site on the Internet and/or via a social networking web site.

Yet still further aspects of the invention provide a system, for example, as described above, in which the server, data processors, mobile devices, portable computer, desktop computers and/or other data processing apparatus of the first aforesaid operator and/or of the other enthusiasts facilitate a challenge by one of those other enthusiasts, e.g., to surpass some or all of the identified tricks and/or measured characteristics of the first aforesaid operator, and/or vice versa—e.g., to engage in a competition.

Related aspects of the invention provide a system, for example, as described above, in which the data processor of a competing enthusiast identifies tricks and/or collects like information measured by a sensing device attached to a skateboard, surfboard, rollerblade boot, or other object operated by that enthusiast, and transmits that to the server, e.g., along with still images, video images, location and/or other information collected as above.

Still yet further related aspects of the invention provide a system, for example, as described above, in which the server, data processors, mobile devices, portable computer, desktop computers and/or other data processing apparatus of the first aforesaid operator and/or of the other enthusiasts initiate communications to operators when their
identified tricks and/or measured characteristics have been exceeded by other enthusiast-operators.

[0031] Still yet further aspects of the invention provide a system, for example, as described above, in which the server, data processors, mobile devices, portable computer, desktop computers and/or other data processing apparatus of the first aforesaid operator and/or of the other enthusiasts facilitate a live competition among operators.

[0032] Other aspects of the invention provide a system, as described above, for example, that specifies a trick to be performed by the first aforesaid operator and/or of the other enthusiasts, and that determines if those tricks were completed successfully. Related aspects allow such an operator or other enthusiast to select a trick to be performed and that determines if the tricks is completed successfully. Related aspects provide such a system that determines a winner as between such an operator and other enthusiast who perform such specified or selected tricks.

[0033] Still yet further aspects of the invention provide a system, for example, as described above, in which the server, data processors, mobile devices, portable computer, desktop computers and/or other data processing apparatus of the first aforesaid operator and/or of the other enthusiasts facilitate display the live competition to other enthusiasts, e.g., by webcast or otherwise.

[0034] Other aspects of the invention provide a system, as described above, for example, that generates an audio output based on the identified tricks and/or measured characteristic(s) of the skateboard, surfboard, snowboard, ski, rollerblade boot, or other object (and/or the user thereof).

[0035] Related aspects of the invention provide a system, as described above, for example, in which the audio output device is disposed remotely from the data processor.

[0037] Other aspects of the invention provide a system, for example, as described above, in which the data processor executes applications software providing one or more of the functions that are attributed above to the mobile device.

[0038] Related aspects of the invention provide sensing devices as described above, e.g., for coupling to a skateboard, surfboard, rollerblade boot, or other object (and/or the operator thereof) and/or for communication with a data processor as described above.

[0039] Related aspects of the invention provide a data processor and/or mobile device incorporating same as described above.

[0040] Related aspects of the invention provide a server, laptop, desktop or other data processor as described above.

[0041] Related aspects of the invention provide methods of operating one or more of the sensing devices, data processors, mobile device, laptops, desktops and/or server as described above.

BRIEF OF ILLUSTRATED EMBODIMENT

[0042] A more complete understanding of the invention may be attained by reference to the drawings, in which:

[0043] FIG. 1A-1B depict a system according to the invention for identifying tricks (or feats) performed on an a skateboard (or other object) and for generating, transmitting, and analyzing data relating to other characteristic(s) of the skateboard;

[0044] FIGS. 2A-2B schematically depicts a sensing device according to the invention for identifying tricks, generating and transmitting data for use in the system of FIG. 1;

[0045] FIG. 3 depicts an aspect of trick identification in a system according to the invention; and

[0046] FIG. 4 depicts a table used in trick identification in other systems according to the invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

[0047] Despite the multitude of advanced technologies found in the components of modern skateboards, very little is dedicated to measuring the tricks that skateboarders perform. The old adage due to Lord Kelvin, “if you can’t measure it, you can’t improve it” applies to skateboarders.

[0048] Systems according to the invention comprise hardware and/or software that identifies and measures the feats (e.g., tricks) that skateboarders and enthusiasts of other sporting and non-sporting activities perform. For sake of convenience, and without loss of generality, such systems will be described in connection with skateboarding in much of the discussion below, though, it will be appreciated that it can be used in connection other activities of motion (here, “sporting” activities) as well.

[0049] As will be evident below, there are several uses of systems according to the invention. They can be used for training skateboarders on new tricks, as well as perfecting old ones. They can be used, as well, to “score” or “rate” particular tricks—whether to test the effectiveness of training or as part of a competition.

[0050] Unlike the prior art, where a skateboarder’s success in mastering a new trick or in proving competency in an old one is based on the opinion of others, systems according to the invention provide unbiased, objective measures. In addition, they provide measures (e.g., trajectory and motion of the skateboard through space) that can be quantified, visualized, replayed, and compared any number of times, e.g., on a computer or smartphone and/or over the Internet.

[0051] In addition to promoting training and competition, systems according to the invention help to form and engage a community of skaters (or others) at festival or larger region—even, around the world. Such systems can also use geolocation to track best scores at a given location, e.g., over a period of time, so that the winner can be declared the “king of the park.”

[0052] As noted above, skateboarders, as well as other are eager to share their progress and are always in search of new venues to do so. They may train or show their tricks in skateparks but, more often, they do so on sidewalks, in driveways, playgrounds, and other spaces that have not been designed for skateboarding.

[0053] Unfortunately, they can typically only display their feats to fellow enthusiasts who are in the same locale at the same time. For example, a skateboarder who has perfected a multiple varial heel flip, is usually limited to proving his/her prowess to friends at the local hangout. One of them might text or “tweet” news of the feat to others, but that is likely to dismissed as unbelievable, particularly, if the feat is
extraordinary. Some of that disbelief might be dispelled by posting of a video of the feat, but even that may be subject to skepticism.

The illustrated embodiment leverages different and unique characteristics of skateboarding and other activities of motion to identify feats and/or to otherwise generate, analyze and/or exchange information regarding those feats and/or other characteristics of the equipment and the environment in which they are performed.

Architecture (FIG. 1A)

FIG. 1A depicts a system 10 according to one practice of the invention for identifying tricks performed on a skateboard 20 and/or for otherwise generating, transmitting, and analyzing data pertaining to motion of the skateboard. Other embodiments employing the teachings hereof and within the ken of those of ordinary skill in the art may be utilized for identifying other feats of motion of the user alone or in connection with other objects. Non-limiting examples of other such objects (and feats of motion) include, inter alia, golf clubs (swing profile), a person diving off a springboard (rotation rate), or a dog on an agility course (path and speed through weave sticks).

The illustrated system includes one or more sensing devices 40 (also referred to here as measurement devices) that are attached to a skateboard 20 and that are in communications coupling with one or more digital data processors, here, in this drawing, represented by digital data processor 60.

Sensing Devices

The sensing devices 40 measure position, motion and/or other physical characteristics of the skateboard 20 and/or its environment. Position measurements can include absolute or relative position (e.g., as determined in accord with GPS satellite signals or otherwise), linearly or in rotation—including, by way of non-limiting example, location, orientation and/or altitude. Referring to the annotated axes 11 shown on FIG. 1A, motion measurements can include linear motion and/or rotation motion, including, for example:

1) roll (denoted “R”, in the drawing)—total angular displacement about the longest principle axis X of the skateboard given relative positioning of the sensors to the skateboard;

2) pitch P—total angular displacement about the second principle axis Y of the skateboard parallel to the ground when the skateboard is at rest on its wheels;

3) yaw (“W”)—total angular displacement about the principle axis Z of the skateboard perpendicular to the ground when the skateboard is at rest on its wheels;

4) acceleration—acceleration detected along the longest axis X of the skateboard;

5) initial pitch—the sign of the pitch P detected nearest the start point of the data window. In the drawing, that sign is indicated by “+” and “−” signs adjacent ends of the curved arrow denoting the pitch P.

Other motion measurements can include speed, jerk, among others. Other characteristics of the skateboard can include orientation of the operator/user, weight of the operator/user and/or other forces and strains on the skateboard, temperature and windspeed, all by way of non-limiting example.

The sensing devices 40 can comprise conventional sensors of the type for measuring linear and/or rotations position and/or motion known in the art, as adapted in accord with the teachings hereof. Thus, for example, the devices 40 may comprise GPS sensors, accelerometers, gyroscopes, magnetometers, temperature sensors, strain sensors, optical sensors, acoustic sensors, RFID (radio frequency identification) and so forth embodied in microelectromechanical systems (MEMS) or otherwise, and all as adapted in accord with the teachings hereof. For example, in some embodiments, optical sensors are utilized alone—or, for example, with LED lasers or other light-emitting devices—to facilitate detecting when the skateboard 20 is engaged in a “grind.” By way of further example, in some embodiments, an RFID receiver chip attached to the skateboard 20 can be used in conjunction with an RFID transmitter chip attached to the user’s shoes (or elsewhere) to facilitate (i) identification and/or orientation of the user.

Placement

The sensing devices 40 can be coupled to any portion of the skateboard 20—though, in some embodiments, placement is dictated by several factors related to standard use cases: where on the board will the sensing devices experience the least damage, what is least intrusive to the skateboarding experience, and what is most aesthetically pleasing.

Significantly, placement is also dictated by location(s) that facilitate measurement by sensing devices 40 (e.g., accelerometers) that are best interpreted by data processor 60 to identify tricks performed on a skateboard (and/or to otherwise provide for the meaningful generation of data pertaining to the skateboard). In this regard, placement can be made in accord with an analytic solution to the three coupled differential equations for rigid body motion known as Euler’s equations. Precise placement in this regard is not critical, however, since the set of motions that constitute skateboard tricks is sufficiently limited to admit coarser methods of distinction (and, hence, allowing more weight to be given to the other placement factors).

By placing the sensing devices on the skateboard asymmetrically along its longest principle axis and approximately symmetrically along the remaining two principle axes one can sense the centrifugal acceleration in the rotating frame necessarily experienced when the skateboard rotates about a non-principle axis during a trick. This hinges on how limited the class of rigid body motions that constitute tricks is: any trick that does not rotate solely about a principle axis necessarily has largest angular velocity in roll and registers non-zero angular velocity about all three principle axes for the duration of a trick. In the standard language of skateboarding the first of these characterizations is tantamount to saying that if two tricks that rotate about a single principle axis are combined, one of them will be a kickflip or a heelflip.

This partially symmetric placement of sensors can be used to detect centrifugal acceleration of the skateboard 20 (or other object) along its longest principle axis, which in turn is useful in developing a myriad of coarse yet unambiguous classifications of rigid body motion. The outlined sensor placement criteria has broad application in many fields outside of skateboarding. Indeed, any activity of motion involving a rigid body that has a distinctly long
principle axis would benefit from this scheme in tracking and classifying rigid body motion.

Riser Pad (FIG. 1B)

[0069] Referring to FIG. 1B, the sensing devices 40 can be embedded, mounted or otherwise fixed to the trucks 26, which connect wheels 28 to deck 22. Alternatively, the devices 40 can be affixed to a surface of the deck 22 or elsewhere on the skateboard.

[0070] Regardless, the sensing devices are preferably mounted to the skateboard 20 in a manner that achieves the desired placement while, at the same time, (i) protecting the devices 40 from damage as the skateboard is stepped upon, grinded and/or slammed during use (e.g., jumped upon by the user, grinded against stair rails, slammed against curbs, and so forth), (ii) permitting access to batteries, sensors and associated logic of the sensing devices 40, (iii) permitting transmission of wireless signals to/from the sensing devices, e.g., without requiring signal penetration through the truck 26, which is typically metal, and/or (iv) permitting recharging of batteries for the devices 40, uploading of data and/or control software, and/or downloading of data.

[0071] A riser pad 24 that achieves the foregoing is illustrated in FIG. 1B. This pad 24, which is generally of a “clamshell” design, includes a base portion 24A, a body portion 24B, and a cover 24C. Those portions may be hinged to one another, as shown in the drawing, though this is not the case of all embodiments. And, while the cover 24C is preferably removable from the other portions 24A, 24B, those other portions may, indeed, be formed as one.

[0072] In the illustrated embodiment, the pad 24 is mounted in a cavity 22A of the deck 22 such that the cover 24C is accessible from the top of the deck (i.e., the side opposite the deck from the truck 26 and wheels 28) and such that the base 24A is accessible—and, preferably, stands proud from—the bottom of the deck 22. The latter permits, in some embodiments, mounting of the truck 26 to the base 24A and, in some embodiments, exposes a port (not shown here), e.g., a charging port and/or data port, for access by the operator when the board 20 is not in use.

[0073] Consistent with the discussion above, the pad 24 and, particularly, the body portion 24B thereof are disposed within deck 22 such that sensing devices 40 mounted within the pad 24 are disposed asymmetrically along the longest principle axis X of the skateboard, while being approximately symmetrically disposed along the remaining two principle axes Y and Z, as shown. Though shown in an open configuration in the drawing, during normal use of the skateboard 20, the body of spacer 24 is disposed in recess 22A and is closed.

[0074] Portions 24A, 24B may be formed of metal, plastic, wood, carbon fiber or other material of suitable durability, e.g., for permanent or semipermanent affixation in deck 22 and for mounting of truck 26, as shown if FIG. 1A. Cover 24C is preferably formed of plastic, wood or other material sufficiently durable to withstand pounding, rubbing or other contact by the operator, yet, which does not interfere with wireless communications, e.g., to/from sensing devices 40 disposed within the pad 24. The various portions 24A-24C preferably includes seals, e.g., O-rings, or the like, that prevent water, dirt and other contaminants from entering the body and, thereby, fouling sensing devices 40 therein.

Multiple Sensing Devices

[0075] In some embodiments, more than one array of sensing devices 40 are be coupled to the skateboard to allow for additional data to be generated regarding the characteristic(s) of interest. For example, a skateboard 20 can have sensing devices, e.g., in spacers 24 that reside above the trucks of both the front and back wheels. In fact, in some embodiments, one or more of those sensing devices 40 is disposed on the user/operator of the skateboard, e.g., on a shoe, boot, sock, pant leg, belt, backpack, and so forth, in order to provide further data for identifying tricks performed on a skateboard and/or for otherwise generating, transmitting, and analyzing data pertaining to motion of the skateboard.

Digital Data Processor 60

[0076] The sensing devices 40 communicate collected measurements to one or more digital data processors—here, depicted as digital data processor 60—for analysis, logging, display and/or retransmission to other devices.

[0077] The data processor(s) can comprise a dedicated device, such as a dedicated microprocessor (or “controller”) that is embedded with the sensing devices 40, e.g., on the skateboard 20, and/or that is housed separately from the sensing devices albeit coupled for communications via Blue tooth, WiFi, cellular, infrared or other wireless or wired transmission medium, or otherwise. An example of the former is microprocessor 44 of FIG. 2. An example of the latter is the digital data processor 60 shown in FIG. 1 and discussed, e.g., in the section below entitled “Digital Data Processor.”

[0078] Alternatively, or in addition, the data processor(s) 60 can be part a multifunction device, e.g., in the case of a data processor that is embedded in a cell phone, personal digital assistant, or other mobile device (collectively, “mobile device”) and that is in communications coupling (again, for example, via Bluetooth, WiFi, cellular, infrared, or other wireless or wired transmission medium, or otherwise) with the sensing devices 40 and/or another data processor (e.g., an embedded microprocessor) that is itself in communications coupling with those devices 40.

Sensing Device—Packaging (FIG. 2)

[0079] As noted above in connection with FIG. 1, the sensing devices 40 can comprise conventional sensors of the type known in the art for measuring position, motion and/or other physical characteristics of the skateboard 20 and/or its environment, as adapted in accord with the teachings hereof. Thus, for example, the devices 40 may comprise GPS sensors, accelerometers, gyrosopes, magnetometers, temperature sensors, strain sensors, and so forth, embodied in microelectromechanical systems (MEMS) or otherwise, and all as adapted in accord with the teachings hereof.

[0080] Referring to FIG. 2A, the sensing devices 40 of the illustrated embodiment comprise linear accelerometer sensor 40a and rotational sensors 40b-40d for measuring, respectively, acceleration along the longest axis X of the skateboard 20; roll (angular displacement about axis X), pitch (angular displacement about axis Y) and yaw (angular displacement about axis Z). As noted above, other embodiments may use other sensors, e.g., GPS sensors, magnetometers, temperature sensors, strain sensors, instead or in addition.
Illustrated sensing devices 40 may form part of an inertial measurement unit or otherwise, and they may be fabricated embodied in microelectromechanical systems (MEMS) or otherwise. In one embodiment, the rotational sensors 40a-40d are embodied in an STMicroelectronics L3G4000D three-axis angular rate sensor, while sensor 40a is embodied in an Analog Devices ADXL345 three-axis accelerometer. These, however, are design choices, from which others skilled in the art may vary in accord with the teachings hereof.

Packaged with the sensors 40a-40d of the illustrated embodiment are microprocessor 44, battery 46, and wireless communication module 48. Together with an appropriate substrate and supporting circuitry, these components form a printed circuit board (PCB) 42 that, in the illustrated embodiment, has a form factor of the type as shown in FIG. 21—a more complete understanding of which PCB may be attained by reference to the schematic of Appendix I hereto. Of course, other embodiments may package these components in other ways—e.g., on PCBs of other configurations, on chipsets, in separate PCBs, and otherwise.

While not shown in the illustrated embodiment, the sensing devices can additionally include a pressure sensor (based on piezo-electric or otherwise). This can be housed on PCB 42, though, more typically, it is mounted directly to deck 22 in order to detect when there is a user on the skateboard 20, when the user is landing on the board (e.g., after a jump), when the user and the board are both in free-flight and/or when the user falls off the board. Output from the pressure sensor can be used in connection with trick determination, e.g., along the lines discussed below and/or it can be reported (directly or by way of microprocessor 44) to digital data processor 60 as another “measured characteristic” of the board 20.

The device 42 also include an audio output (not shown) that generates an audio signal (e.g., a song and/or sound or series of sounds), e.g., in the manner of the audio output discussed below in connection with digital data processor 60 or otherwise.

Battery

Battery (or other power source) 48 provides power for operation of unit 42 and/or the constituent elements thereof. This is a conventional battery (or other power source) of the type known in the art for household or light industrial use, though other batteries and/or power sources may be used as well or in addition—all as adapted in accord with the teachings hereof. Suitable batteries include, for example, alkaline, nickel-metal hydride, nickel-cadmium, lithium, carbon zinc, and so forth. Preferably battery 48 is rechargeable and/or removable (e.g., via opening of riser cover 24c).

In the illustrated embodiment, battery 48 may be recharged (and its charge, for example, checked) via application of power to a USB port on unit 42, access to which may be gained via the base 24a or cover 24c of the riser 24. (That access may be covered, e.g., by a removable plug or otherwise to prevent contamination). In other embodiments, recharging may be provided for via a standard power adapter port, via inductive charging or otherwise.

Communication Module 46 Enables the Transfer of Software

Communication module 46 enables the transfer of software (e.g., for purposes of reprogramming the unit 42), control parameter and/or data between the unit 42 (and, particularly, for example, the sensors 40a-40d and/or microprocessor 44) and external devices, e.g., digital data processor 60. The module 46 can support wired transfers, e.g., via the aforementioned USB port or otherwise. In preferred embodiments, it supports wireless transmissions, instead or in addition. This can include Bluetooth, WiFi, cellular, infrared or other wireless protocols.

Module 46 can be constructed and operated in the conventional manner known in the art suitable for supporting the aforesaid and other wired and wireless protocols—as adapted in accord with the teachings hereof.

Software of the type suitable for execution by microprocessor 44 to effect operation of module 46 of the illustrated embodiment is provided below. It will be appreciated that this represents but one technique for configuring the microprocessor 44 to support such operation and that other techniques so configuring the microprocessor are within the scope of the invention.
device_number = raw input("Connect to (enter number): ")
if int(device_number) in range(number_of_devices):
    return device_number
else:
    get_user_number_input(number_of_devices, device_number)
    device_number = get_user_selection(len(nearby_devices))
    return nearby_devices[device_number]

# connect to IMU and return IMU Bluetooth socket
def getIMUsocket(address = 00:06:66:42:21:85):
    sock = bluetooth.BluetoothSocket(bluetooth.RFCOMM)
    #alt address = raw input(Enter imu's Address (Default: ' + address + ')
    if alt_address != ' ':
        address = alt_address
    nearby_devices = bluetooth.discover_devices()
    if len(nearby_devices) > 1:
        print("Could not connect to device with address " + address + ","
        return None
    sock = bluetooth.lookup_name(address)
    sock.connect((address, 1))
    sock.setblocking(True)
    return sock

# parses new sensor data into co-temporal sets
def parseIMUdata(rawdata):
    num_lines = 40
    bufList = string.replace(string.replace(rawdata,"AN:'",")agner:1",":",split("r:\n")
    line = np.zeros((num_lines,7)) # elements in a complete line => 7
    num_lines = len(bufList)
    if rawdata[-1] != "\r\n":
        num_lines = num_lines + 1
    for i in range(num_lines):
        line[i] = int(bufList[i].split("\r\n"))
    return line
for i in range(num_lines):
    try:
        if len(bufList(i)) == 16:
            data_array = np.fromstring(bufList[i], dtype=np.uint8)
            # timestamp
            line[i,0] = 2**32*data_array[0] + 2**16*data_array[1] +
            2**8*data_array[2] + data_array[3]
            # gyroscope data
            line[i,3] = 2**8*data_array[8] + data_array[9]
            # accelerometer
        else:
            line[i,0] = -1
    except:
        line[i,0] = -1
return [num_lines, line]

# Open and return IMU log file object
def openIMUfile(filepath='\input(Enter filepath (Default: + filepath +)')
if alt_filepath = *:
    alt_filepath = alt_filepath
if alt_filepath != ''.input(Enter filepath (Default: + filepath +))
    filepath = alt_filepath
    return open(filepath, 'w')

Microprocessor

Illustrated microprocessor 44 controls and/or configures the unit 42 and/or the constituent elements thereof. The microprocessor 44 can perform any number of functions, as will be appreciated by a person skilled in the art, depending on the particular application for which the sensing devices 40 are used. By way of non-limiting example, the microprocessor 44 can power-up, power-down, “sleep,” reset, pair/unpair, and/or set operational parameters (including, level setting) for unit 42, module 46 and/or sensors 40a-40d. By way of further example, microprocessor 44 can effect software, control parameter and/or data transfer between digital data processor 60 and unit 42, module 46 and/or sensors 40a-40d.

Thus, for example, in order to extend the life of the battery 48, the microprocessor 44 can configure sensing devices 40 and/or communications module 48 to enter sleep mode during non-use or inactivity, e.g., if the communication module 46 is unable to connect to the digital data processor 60 for a pre-determined time, e.g., five minutes), in response to a command from that processor 60, in response to a user deactivation command (e.g., a triple-tap on the skateboard 20). And, by way of further example, the microprocessor 44 can configure the communications module 48 to operate in lower power mode when practical. To further extend battery 48 life, the microprocessor 44 preferably activates the sensing devices 40 independently of the communication module.

As will be appreciated by those skilled in the art, various ones of the control and/or configuration operations attributed to the microprocessor 44 may be handled via other functionality in the module 42. Thus, for example, one or more parameters may be burned into read-only memory modules (not shown) provided with the unit 42, may be “hardwired” into circuitry of the PCB, or otherwise, all consistent with the teachings hereof.

By way of further example, microprocessor 44 can perform data conditioning (e.g., normalization), data reduction, data compression and other preprocessing of data from sensors 40a-40d before it is sent to digital data processor 60. It can also detect fault in operation of the unit 42, module 46 and/or sensors 40a-40d, forcing notification to digital data processor 60 and/or to an operational LED and/or display panel (not shown) and/or audio output of unit 42 in case of such detection.

In some embodiments, processing of data generated by sensors 40a-40d is the province of separate digital data processor 60. However, in the illustrated embodiment, microprocessor 44 performs one or more of those tasks—and particularly, by way of non-limiting example, the processing of data generated by those sensors to identify tricks (or other feats) performed on the skateboard 20 (or other object).

The illustrated microprocessor 44 also performs control associated with such trick (feat) identification. This includes, by way of example, powering-up or waking the sensors 40a-40d in response to user activation—e.g., double-tapping of the skateboard 20 by the user. This also includes, by way of example, detecting trick (or feat) start, e.g., based on jerk detection or other characteristic changes in forces or motions measured by the sensors. And, it includes by way of example, uploading the identity of detected tricks to the digital data processor 60, e.g., along with underlying or other sensor readings.

In this latter regard, for example, the microprocessor 44 can effect uploading of the identity of an identified trick to the digital data processor 60, along with position information from a GPS sensor (not shown), time/date information from an onboard clock (not shown), max/min velocity and acceleration readings sensor 42a, and so forth—all by way of example. By way of further example, microprocessor 44 can effect uploading of a log of collected sensor readings, if it is unable to identify therefrom a particular trick—or, in some embodiments, even if it is able to identify a trick. An advantage of such logging is, for
example, that it makes possible validating what tricks and other actions an operator indeed performed on the skateboard (or other object).

Instead of, or in addition to, uploading trick identity and/or underlying or other sensor readings, the microprocessor can effect notification when pre-selected trick(s) or feats—such as, in the case of skateboard 20, an "Ollie"—is/are identified. Such notification can be transmitted to the digital data processor 60. Alternatively or in addition, such notification can be effected via an alert to the aforementioned operational LED and/or display panel (not shown) of unit 42, to the aforementioned audio output, or otherwise.

Indeed, such a notification can be transmitted or otherwise effected when the processor detects an attempted, but failed, trick.

**Trick Detection**

As noted above, in the illustrated embodiment microprocessor 44 processes of data generated by those sensors 40 to identify tricks (or other feats) performed on the skateboard 20 (or other object). An appreciation of this may be attained by reference to the discussion that follows, as well as that provided elsewhere herein. Though attributed to microprocessor 44, it will appreciated that trick (feat) detection can be performed by digital data processor 60 or other functionality, all in accord with the teachings hereof.

In the illustrated embodiment, the microprocessor 44 begins trick identification with processing data from the gyroscopes 40β-40d and accelerometers 40a to determine what segment, or "data window", of a data stream to compare against what an expected trick signature (i.e., what a trick is expected to look like in terms of sensor data).

In order to locate such data windows, the illustrated microprocessor 44 first sets a threshold for angular displacement. If the magnitude of angular displacement sensed by the gyroscopes is beyond this threshold about any axis, microprocessor 44 considers this a potential start point of a data window in which to identify tricks.

To determine a potential end point of a data window, the microprocessor 44 sets a separate threshold on the rate of change of angular displacement. This relies on the assumption that when a trick is landed the skateboard 20 suddenly stops rotating (e.g., when it is "caught" by the user); this causes sharp fluctuations in angular displacement data.

Once a start point and end point have been identified, a final step in identifying a data window is to check that a "reasonable" amount of time has passed from the start point to the end point. Again, microprocessor 44 sets a threshold on the difference of the time stamp on a potential end point and the time stamp on a potential start point. If this difference is greater than the time threshold, then microprocessor 44 proceeds to compare the data in the identified data window to the signature of what is expected for each trick.

In the illustrated embodiment, there are n salient features of gyroscope and accelerometer data used to identify tricks, and each trick is assigned a collection of n-tuples. Each n-tuple assigned to a particular trick is considered a signature of that trick. If one of the signatures of a trick appears in a data window, that trick is registered as detected.

Referring back to FIG. 1, in the illustrated embodiment, illustrated features include:

1) roll (denoted "R", in the drawing)—total angular displacement about the longest principle axis X of the skateboard given relative positioning of the sensors to the skateboard;

2) pitch P—total angular displacement about the second principle axis Y of the skateboard parallel to the ground when the skateboard is at rest on its wheels;

3) yaw ("W")—total angular displacement about the principle axis Z of the skateboard perpendicular to the ground when the skateboard is at rest on its wheels;

4) acceleration—acceleration detected along the longest axis X of the skateboard;

5) initial pitch—the sign of the pitch P detected nearest the start point of the data window. In the drawing, that sign is indicated by "+" and "−" signs adjacent ends of the curved arrow denoting the pitch P.

Each of these features, or "parameters," is bounded by thresholds and has between three and six modes. Referring to FIG. 3, the gray areas indicate the thresholds within which a given trick rotating about the longest principle axis (having roll) would be recognized.

Each of these parameters assumes a value specifying what range, given threshold, certain aspects of gyroscope and accelerometer data fall in. Each combination of values for each parameter unambiguously specifies the type of motion a skateboard has undergone during a data window, whether it be a trick or not.

Parameter (1) reflects how much roll, if any, the skateboard rotates through during the data window. Practically, this is measuring how much kickflip or heelflip has happened during a trick. Notice that any trick that does not rotate primarily about a principle axis necessarily has some non-zero roll. Also, the skateboard rotates most easily about its longest principle axis, since the skateboard has the smallest moment of inertia in this dimension. For these reasons, parameter (1), unlike parameters (2) and (3), is useful for identifying and differentiating tricks that rotate about a single principle axis (namely the longest axis of the skateboard) and tricks that combine rotations about more than one principle axis, such as a variab flip or a 360 flip. The angular velocity in roll is roughly constant for the bulk of a given data window, and the thresholds on parameter (1) determine practically how many kickflip or heelflip rotations have occurred during the course of trick.

Parameter (2) is similar to (1), but reflects the amount of pitch the skateboard rotates through during the data window. Parameter (2) differs from (1) in that it is only useful in determining if rotation about a single principle axis is enough for a trick to have been completed. Practically, this amounts to determining whether a data window contains data for an impossible or a front foot impossible. Tricks that rotate about a non-principle axis do make gyroscopes register pitch, but in a non-obvious way. This behavior is addressed by parameter (4).

Parameter (3) is entirely similar to parameter (2), save that the information it encodes is the angular displacement about the third principle axis, or yaw. Practically this amounts to determining whether a data window contains data for a shuvit, frontside or backside, and how much. Again, for tricks that rotate about a non-principle axis yaw, exhibit non-obvious behavior and captured by parameter (4).
For tricks that rotate about a non-principle axis, as reasoned above, rotation about the longest principle axis happens the fastest. Since the gyroscopes are fixed to the skateboard, this means that during the course of a trick the angular velocity registered by the sensors about, say, the principle axis corresponding to yaw will exhibit sinusoidal behavior, likewise for pitch. This makes physical sense, yet confounds the intuition of the typical skateboarder. For example, conventionally a varial flip is described as 360 degrees of roll (a kickflip) combined with 180 degrees of yaw (a shuvit). However, gyroscopes data taken during the course of a varial flip results in roughly 360 degrees of roll and two out of phase sinusoids for pitch and yaw. Difficulty arises when one tries to distinguish tricks which conventionally differ by a 180 degree rotation in yaw, for example the varial flip and the 360 flip (360 degrees in roll and 360 degrees in yaw). The “shape” of the gyroscopic data is roughly the same, and differs mostly in the amplitudes of the sinusoids. These amplitudes do not readily yield to the same methods of setting thresholds using in parameters (1)-(3). Instead, here the microprocessor 44 exploits the asymmetric position of the sensors on the skateboard to detect centrifugal acceleration.

Parameter (4) reflects the accelerometer data from the longest axis of the skateboard. The accelerometer experiences a centrifugal acceleration that is proportional to the square of the angular velocity registered in pitch and yaw by the gyroscopes, as exemplified by the relations below:

\[ a = \omega^2 \Omega \]

\[ a = 2\omega^2 \Omega \]

In this way, the difference tricks intuitively described as being a 180 degree rotation in yaw different becomes clear. Notice that if the sensors were placed symmetrically on the body, no centrifugal acceleration would be measured and such a scheme of detection would be impossible.

Parameter (5) reflects the initial direction of pitch: either positive, negative or zero. Practically, this determines the “stance” from which a trick is executed, either regular (negative) or nollie (positive) or the trick does not pop off the ground (zero).

Code

Software of the type suitable for execution by microprocessor 44 to effect trick detection in accord with the foregoing is provided below. It will be appreciated that this represents but one technique for configuring the microprocessor 44 to support such detection and that other techniques so configuring the microprocessor are within the scope of the invention.

Software of the type suitable for execution by microprocessor 44 to test operation of a module 42 constructed in accord with the teachings hereof is provided below. It will be appreciated that this represents but one technique for configuring the microprocessor 44 to support such testing are within the scope of the invention.
Alternative

[0121] Alternative embodiments of the invention utilize other techniques for trick identification. One such alternate embodiment bases such identification on measuring the changes in the angular orientation of the skateboard 20 along each of the axes X, Y, and Z from the start to the end of the trick. Those changes, denoted Θx, Θy, and Θz, respectively, are used as a look-up value for a database or table associated such values with names of specific tricks.

[0122] According to this embodiment, the microprocessor 44 determines the start of a trick by monitoring an accelerometer (e.g., 40a) to identify values of acceleration of the skateboard 20 along one or more of the axes X, Y, and Z indicative of the start of a trick—or, alternatively, by monitoring other sensors to detect taps or signalizing by the user himself/herself that a trick is about to start. The microprocessor can similarly determine the end of the trick. Depending on the types of angular motion sensors employed in unit 42, the microprocessor continually monitors their output while the trick is in progress (and/or alternatively, at the start and the end of the trick) in order to determine Θx, Θy, and Θz.

[0123] The microprocessor utilizes those values as a look-up into a table of the sort shown in FIG. 4 that associates such values, as noted above, with specific tricks. If a matching entry is found, i.e., a table entry bearing values of Θx, Θy, and Θz matching those determined from the sensors, the microprocessor 44 reads the trick name from that entry and uploads it and/or underlying or other sensor readings to digital data processor 60, logs the same to storage on-board unit 42, and/or generates a notification.

[0124] In some embodiments, the table shown in FIG. 4 is populated empirically, e.g., by taking and averaging values of Θx, Θy, and Θz measured on skateboard 20 by experts to perform then named tricks. In other embodiments, the table is populated based on hypothetical calculations, modeling or otherwise.

[0125] In these and other embodiments, to account for potential errors in sensor readings (both during use of the skateboard 20 by the experts to populate the table and by normal users in performing tricks), the table can be populated, not only with values of Θx, Θy, and Θz that are associated with each trick, but also with expected deviations in those values, here, denoted σx, σy, σz associated, respectively. Those expected deviations can be determined empirically, based on measurements taken during expert performance, or otherwise.

[0126] In these embodiments, the table look-up referred to above can be supplemented to accommodate matching values of Θx, Θy, and Θz measured at “runtime” (i.e., when a normal user is performing tricks for identification) with the table values in view of the deviations. When the runtime-measured values match the Θx, Θy, and Θz values associated with two or more tricks in the table with the deviations taken into account, the microprocessor can resolve the potentially ambiguity in identification by choosing the trick for which the root-mean deviation of the runtime-measured values vs the table values of Θx, Θy, and Θz is smallest.

[0127] Some embodiments of the invention utilize additional information to resolve such ambiguities and/or to other determine which of various tricks were performed, for example, based on additional information indicated by one or more sensor(s) on the board (e.g., linear acceleration, direction of movement) or on the user (e.g., the user’s stance on the skateboard). In the event that an actual indication, or a combination of actual indications, are associated with more than one trick in the table of FIG. 4, that can be reflected in the table, as well, and the microprocessor 44 can take it into account when performing trick identification and/or disambiguation.

Digital Data Processor

[0128] Referring back to FIG. 1, data processor 60 can comprise a dedicated device (e.g., a desktop or laptop computer) or it can be part a multifunction device, e.g., as in the case of a data processor that is embedded in a cell phone, personal digital assistant, or other mobile device (collectively, “mobile device”). In the illustrated embodiment, processor 60 is in communications coupling with the unit 42 and, more particularly, for example, microprocessor 44 and/or sensing devices 40, e.g., via Bluetooth, WiFi, cellular, infrared, or other wireless or wired transmission medium.

[0129] In various embodiments, the data processor 60 processes data regarding skateboard 20 and, more particularly, data from with sensors 40a-40f and/or the microprocessor 44 and, optionally, in some embodiments with other “nodes” (as discussed below) to perform one or more of the following functions. Such processing can be performed on the digital data processor 60 using conventional software and data analysis techniques as adopted in accord with the teachings hereof:

[0130] process information received from unit 42, and still more particularly, for example, microprocessor 44 and/or sensing devices 40 to quantitatively or qualitatively characterize the motion, location and/or other characteristics of the skateboard;

[0131] identify tricks performed on the skateboard 20 (or other object) (e.g., in embodiments where such identification is not performed by microprocessor 44 and/or in which auxiliary processing by the data processor can facilitate and/or confirm such identification);

[0132] log identified tricks and/or characteristics of the skateboard and/or its environment measured by the sensing devices 40;

[0133] associate identified tricks and/or characteristics of the skateboard and/or its environment measured by the sensing devices 40 with information identifying the skateboard 20, its user, the time/place of trick performance and/or characteristic measurement, and/or multimedia content (e.g., images, video, or audio clip) associated with any of the foregoing or otherwise;

[0134] generate displays, visual notifications and/or audio notifications regarding identified tricks, measured characteristics, and/or associated information on an LED and/or display panel (not shown) and/or audio output associated with the data processor 60 and/or the skateboard 20; and/or
exchange information regarding identified tricks, measured characteristics, and/or associated information with central servers, central stores, other nodes, the Internet and/or otherwise.

By way of non-limiting example, in one embodiment, the digital data processor 60 can supplement trick identification (if any) performed by the microprocessor by analyzing other aspects of skateboard use, e.g., maximum height attained during a skateboard session, longest time in the air during the session, fastest speed attained, longest sustained run, and so forth. It can perform one or more of the aforementioned functions with the results of these analyses, as well or instead. Of course, in some embodiments these analyses can be performed by the microprocessor 44 instead or in addition.

In some embodiments, a given data processor 60 (e.g., a cell phone, PDA or computer) may be capable of operation with multiple different skateboards (or other objects) 20, concurrently or one-at-a-time. This can facilitate, for example, the use of a cell phone 60 with multiple objects (e.g., skateboards, surf boards, etc.) equipped in accord with the teachings and owned by the given user or, conversely, by multiple such objects owned by different persons (e.g., friends, competitors, etc.).

Moreover, in some embodiments, the microprocessor 44, unit 42 and/or cell phone (or digital data processor) 60 are equipped to communicate to one another and/or to central servers, central stores, and/or other nodes, the Internet, or otherwise via a mesh network, established among themselves or otherwise. This can, for example, facilitate communication among skateboards 20 in the same recreational park, e.g., when only a few of the users have cell phones.

Referring back to FIG. 1, data processor 60 can comprise a dedicated device (e.g., a desktop or laptop computer) or it can be part of a multifunction device, e.g., as in the case of a data processor that is embodied in a cell phone, personal digital assistant, or other mobile device (collectively, "mobile device").

It includes one or more modules for the receiving, transmitting, processing, storage, generation, and/or display of data of the type conventionally associated with such dedicated and/or multifunction devices, all as adapted in accord with the teachings hereof. For example, the data processor 60 can include a store that is configured and operated utilizing conventional database techniques (as adapted accord with the teachings hereof) to record information regarding identified tricks and/or characteristics of the skateboard and/or its environment measured by the sensing devices 40, e.g., for later access by the skateboard user or others.

It can also include an audio output device or module that generates an audio output (e.g., a song and/or a sound or series of sounds), e.g., in response to information received from the skateboard and/or the other nodes (if any), in response to user prompts, or otherwise.

As shown in the drawing, data processor 60 is in communications coupling with the skateboard 20 and, more particularly, unit 42, and still more particularly, for example, microprocessor 44 and/or sensing devices 40, e.g., via Bluetooth, WiFi, cellular, infrared, or other wireless link.

By way of further example, digital data processor 60 can also include a keypad, a camera, or a microphone or other peripherals capable of generating multimedia content (e.g., text, images, video, and/or audio). Indeed, a suitably equipped digital data processor 60, can download or acquire such content from other devices and/or from the Internet. Regardless, as above, the digital data processor 60 can display or log that content along with identified tricks and/or characteristics of the skateboard and/or its environment; can use that multimedia content in visual notifications and/or audio notifications regarding identified tricks and measured char-
acteristics; can supply that content to central servers, central stores, and/or other nodes; and/or can use that content in connection with processing information received from unit 42, and still more particularly, for example, from microprocessor 44 and/or sensing devices 40.

[0148] In the foregoing ways, the digital data processor 60 can associate multimedia content with identified tricks and/or other characteristics of skateboard and/or its environment. In an embodiment where the digital data processor 60 is, for example, a smartphone carried in the pocket of the skateboarder, the foregoing provides a convenient way to associate pictures of a skateboard ramp, a video of a jump, or a song that was played while performing a trick, etc., with particular feats by the skateboarder.

[0149] In some embodiments, the digital data processor “automatically” associates such content with identified tricks and/or other characteristics—e.g., as where it associates a pre-stored photo of the user and/or his/her skateboard (or other equipment) and/or a pre-selected song with the identified trick and/or other characteristics for display, logging, notification, or supply to other servers, stores and/or nodes.

Audio Output

[0150] In one embodiment, the digital data processor 60 includes an audio output module 60a that generates audio output, e.g., a song selected by the user, a pre-recorded sound, a synthesized sound, or otherwise. The module 60a may comprise one or more speakers that are embedded with microprocessor 44, e.g., on the skateboard 20, and/or that are housed separately from it, albeit coupled for communications via Bluetooth, infrared or other wireless or wired transmission medium. Alternatively, or in addition, module 60a can be part mobile device that is in communications coupling (e.g., via Bluetooth, WiFi, cellular, infrared, or other wireless or wired transmission medium, or otherwise) with the digital data processor 60. Regardless, the module 60a may arranged for mono playback, stereo playback (e.g., as via the headphones illustrated in FIG. 1) or otherwise.

[0151] Audio output may be activated by the user and its volume, duration or other characteristics controlled by way of a switch (not shown) or otherwise. Alternatively, or in addition, the audio output can be a sound or series of sounds generated in response to data received by the digital data processor 60 from the sensing device 40 regarding a trick or characteristic of the skateboard 20.

[0152] For instance, as the skateboard user performs a specific trick or the skateboard attains a certain characteristic (e.g., a pre-determined speed, height, etc.), the digital data processor 60 can control the audio output device to generate a sound or series of sounds to alert the user. For example, when unit 42 detects that the user is performing an “ollie,” the digital data processor 60 can cause the audio output device to generate a loud crashing noise when the skateboarder kicks down on the back edge of the skateboard. By way of another non-limiting example, the digital data processor can cause the audio output device to generate a “whirling” sound when the skateboard 20 is being spun.

[0153] In another exemplary embodiment, digital data processor can cause the audio output device to generate an audio output (e.g., a song with a given rhythm) that is manipulated based on the characteristic(s) of the skateboard 20. By way of non-limiting example, the playback of the song can be sped up or slowed down in response to the speeding up or slowing down, respectively, of the skateboard 20. An increase in height (e.g., a jump), for example, of the skateboard 20 can amplify the high tones of the audio output, while a decrease in height (e.g., a landing) can amplify the low tones. Variations in the audio output can also prompt the user (e.g., skateboarder), for example, to perform a certain task (e.g., speed up) or alert the user to attempt a new action.

[0154] In this way, the digital data processor 60 can be used as a learning tool. In reference to a certain action desired to be performed by an skateboarder, for example, the audio output device can generate audio output (e.g., a signal) to alert the user to perform a sequence of actions, or perform the next in a sequence of actions, in order to attain the desired characteristic(s).

[0155] In addition to, or in the alternative to, outputting the audio output in real-time, the digital data processor 60 can associate an audio signal with identified tricks and/or characteristics of the skateboard and/or its environment measured by the sensing devices 40. If the user (or another) subsequently accesses a stored record of that trick or other characteristic, the digital data processor 60 or other device can replay the associated audio signal—e.g., allowing the user or another to relive the occasion.

Graphical Display

[0156] In one embodiment, the digital data processor 60 is coupled to an LCD or other display for presentation of information regarding identified tricks, characteristics of the skateboard and/or its environment, and/or associated information of the type discussed above. This can include, for example, display of tables, graphs, scores, virtual images (or a series of images), video, plots, or other graphic or textual representations of the trick, other characteristic(s) of the skateboard 20 and/or associated information. In some embodiments, the digital data processor can be responsive to user input to manipulate the display, e.g., zoom, standardize, filter, and so forth.

[0157] The digital data processor 60 can drive the LCD or other display to present multimedia content associated with identified tricks and/or characteristics of the skateboard, for example. This can be, for example, a photograph or video of the particular trick or motion being performed. Alternatively or in addition, it can be a virtual snapshot or video of the skateboard 20 as it performs, for example, a particular motion or trick. As will be appreciated by the skilled artisan, the virtual representation of the kinetic information can be generated by the digital data processor 60 in accord with known methods and algorithms, adapted in view of the teachings herein.

[0158] By way of non-limiting example, processor 60 drives the display to render a virtual display of skateboard 20 in three-dimensions based on the data generated by the sensing device 40. The display interface 62e can be configured such that the virtual display of the skateboard 20 can be repositioned in virtual space (e.g. rotated) by user interaction. Moreover, in some embodiments, the processor 60 drives the display to overlay renderings of two or more iterations of a trick, based on the data generated by the sensing device 40, to make it easy to see variation.

[0159] In one embodiment, the user of the primary digital data processor 60 can control the frame rate and virtual camera angle of the virtual display of the skateboard 20 such that the user can view the skateboard 20 as it performed a
particular action to see, for example, how the object 20 moved over time. Panda-3D, an open source three-dimensional game engine is an example of suitable software for use in accord with the teachings herein.

[0160] Further, if the physical location at which the action was performed is known, the processor 60 can drive the display to model that location and to overlay on it a display of the skateboard in motion, based on the data generated by the sensing device 40.

MultiNodal System

[0161] A system 10 of the type shown in FIG. 1 and described above can form one “node” in a larger system that includes, in addition to system 10, one or more other such systems. The respective microprocessors 44 and/or digital data processors 60 of those systems may communicate with with one another on a peer-to-peer basis. Alternatively, or in addition, those systems may be coupled to a central server for logging of identified tricks, skateboard characteristics and/or associated information generated by the systems 10. Moreover, they may be coupled to a central server that facilitates the exchange of such tricks, characteristics and/or associated information between the nodes, e.g., in support of a social network, to facilitate competitions or otherwise, as discussed by way of example in incorporated-by-reference PCT Application No. PCT/US11/46423, filed Aug. 3, 2011, and published as WO 2012/018914 on Feb. 9, 2012, entitled “Digital Data Processing Systems And Methods For Skateboarding and Other Social Sporting Activities,” and U.S. application Ser. No. 13/197,429, filed Aug. 3, 2011, and published as US-2012-0116714-A1 on May 10, 2012, entitled “Digital Data Processing Systems And Methods for Skateboarding and Other Social Sporting Activities,” both of which PCT and US applications claim the benefit of priority of U.S. Patent Application Ser. No. 61/370,439, filed Aug. 3, 2010, U.S. Patent Application Ser. No. 61/371,161, filed Aug. 5, 2010, and U.S. Patent Application Ser. No. 61/386,207, filed Sep. 24, 2010. Reference is had in this particular regard and by way of non-limiting example, to the system 10' shown in FIG. 4 of those respective applications and discussed in the accompanying text.

CONCLUSION

[0162] Described above are methods and system meeting the objects and goals set therefor. Those skilled in the art will appreciate that the embodiments shown in the drawings and described in the accompanying text are merely examples of the invention and that other embodiments, incorporating modifications and changes therein and including combinations of foregoing embodiments, fall within the scope of the invention.

[0163] Thus, for example, although the figures and corresponding text hereof are principally directed to embodiments employing skateboards, the teachings hereof may be utilized for identifying other feats of motion of the user alone or in connection with other objects. An enumeration of example such objects is provided elsewhere herein.
Appendix I
In view of the foregoing, what we claim is:

1. A system for skateboarding, comprising
   A. a skateboard,
   B. one or more sensors that are coupled to the skateboard to measure one or more characteristics thereof,
   C. a data processor that is in communications coupling with the one or more sensors and that identifies a trick performed on the skateboard.

2. The system of claim 1, wherein the data processor identifies the trick based, at least in part, on correspondence between characteristics of the motion measured by the one or more sensors and a signature associated with each of one or more tricks.

3. The system of claim 1, in which one or more of the sensors are coupled to a user of the skateboard.

4. The system of claim 1, in which one or more of the sensors is gyroscopic and/or otherwise measures rotation of the skateboard and/or the user thereof.

5. The system of claim 1, in which one or more of the sensors measure rotation around at least two axes of the skateboard.

6. The system of claim 1, in which one or more of the sensors measure rotation around at least three axes of the skateboard.

7. The system of claim 1, in which one or more of the sensors are any of accelerometers, magnetometers, global positioning sensors, and strain sensors.

8. The system of claim 1, in which one or more of the sensors are capable of measuring any of speed, acceleration, jerk, yaw, pitch, and roll of the skateboard and/or the user thereof.

9. The system of claim 1, wherein the data processor is coupled to the skateboard and/or the user thereof.

10. The system of claim 1, wherein the data processor comprises an add-on (i.e., is retrofitted) to the skateboard.

11. The system of claim 1, wherein the data processor is integral to the skateboard.

12. The system of claim 1, wherein the data processor is any of a clip-on, wearable, pocketable, or carry-along device.

13. The system of claim 1, in which the data processor is disposed remotely from the skateboard.

14. The system of claim 13, in which the data processor comprises part a multifunction device.

15. The system of claim 14, in which the multifunction device is any of a cell phone, personal digital assistant, or other mobile device.

16. The system of claim 15, in which the digital data processor is coupled for wireless communications with one or more of the sensors.

17. The system of claim 16, wherein the digital data processor any of logs and/or displays measurements received from the sensor.

18. The system of claim 1, comprising two or more digital data processors.

19. The system of claim 18, wherein a first said digital data processor is coupled to the skateboard and wherein a second digital data processor is disposed remotely from the skateboard but is in communications coupling with any of the first said digital data processor and the one or more sensors.

20. The system of claim 19, wherein the first digital data processor performs said trick identification based on measurements made by the one or more sensors.

21. The system of claim 20, wherein the first digital data processor transmits the trick identifications to the second digital data processor.

22. The system of claim 21, wherein the first digital data processor transmits the trick identifications to the second digital data processor along with measurements from one or more sensors.

23. A method for skateboarding, comprising
   A. measuring one or more characteristics of motion of a skateboard with one or more sensors,
   B. with a data processor that is in communications coupling with the one or more sensors, identifying a trick performed on the skateboard.
   C. where the identifying step includes finding a correspondence between characteristics of the motion measured by the one or more sensors and a signature associated with each of one or more tricks.

24. A system for sporting activities, comprising
   A. an object,
   B. one or more sensors that are coupled to the object to measure one or more characteristics thereof,
   C. a data processor that is in communications coupling with the one or more sensors and that identifies a trick performed with the object.

25. The system of claim 24, wherein the data processor identifies the trick based, at least in part, on correspondence between characteristics of the motion measured by the one or more sensors and a signature associated with each of one or more tricks.

26. The system of claim 24, in which one or more of the sensors are coupled to a user of the object.

27. The system of claim 24, in which one or more of the sensors is gyroscopic and/or otherwise measures rotation of the object and/or the user thereof.

28. The system of claim 24, in which one or more of the sensors measure rotation around at least two axes of the object.

29. The system of claim 24, in which one or more of the sensors measure rotation around at least three axes of the object.

30. The system of claim 24, in which one or more of the sensors are any of accelerometers, magnetometers, global positioning sensors, and strain sensors.

31. The system of claim 24, in which one or more of the sensors are capable of measuring any of speed, acceleration, jerk, yaw, pitch, and roll of the object and/or the user thereof.

32. The system of claim 24, wherein the data processor is coupled to the object and/or the user thereof.

33. The system of claim 24, wherein the data processor comprises an add-on (i.e., is retrofitted) to the object.

34. The system of claim 24, wherein the data processor is integral to the object.

35. The system of claim 24, wherein the data processor is any of a clip-on, wearable, pocketable, or carry-along device.

36. The system of claim 24, in which the data processor is disposed remotely from the object.

37. The system of claim 36, in which the data processor comprises part a multifunction device.

38. The system of claim 37, in which the multifunction device is any of a cell phone, personal digital assistant, or other mobile device.
39. The system of claim 38, in which the digital data processor is coupled for wireless communications with one or more of the sensors.

40. The system of claim 39, wherein the digital data processor any of logs and/or displays measurements received from the sensor.

41. The system of claim 24, comprising two or more digital data processors.

42. The system of claim 41, wherein a first said digital data processor is coupled to the object and wherein a second digital data processor is disposed remotely from the object but is in communications coupling with any of the first said digital data processor and the one or more sensors.

43. The system of claim 42, wherein the first digital data processor performs said trick identification based on measurements made by the one or more sensors.

44. The system of claim 43, wherein the first digital data processor transmits the trick identifications to the second digital data processor.

45. The system of claim 44, wherein the first digital data processor transmits the trick identifications to the second digital data processor along with measurements from one or more sensors.

46. A method for sporting, comprising
A. measuring one or more characteristics of motion of an object with one or more sensors,
B. with a data processor that is in communications coupling with the one or more sensors, identifying a trick performed with the object.
C. where the identifying step includes finding a correspondence between characteristics of the motion measured by the one or more sensors and a signature associated with each of one or more tricks.