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LOCKING SYSTEM

Technical Field of the Invention

5 The present invention relates to a locking system.

Background of the Invention

Various forms of locking systems have been developed for preventing unauthorised
10 access to, or removal of, coveted items. For example, key operated padlocks are used
to securely close locker doors, whereby access to the locker can typically only be
gained if one has the key at hand. Padlocks typically include a detachable lock
coupled to the an object by a pivotable hook. Difficulties can arise with such systems
if the key is lost. In such cases, unless a replacement key can be found, the locker
15 will need to be forcefully opened. This process can be costly and time consuming.
Similar difficulties occur with key locks on vehicles, houses, etc.

Further difficulties can arise in situations where the key is stolen. In such a case, the
locker owner may learn all too late the key is missing and suffer loss at the hands of
20 the thief.

Some of the above-described issues with key based locking systems can be addressed
with password user authentication. However, such systems require cumbersome input
devices such as keypads, or touch screen or any type of key press keys. Such
25 requirements make password based systems impractical for locking systems where
space is restricted.

It is generally desirable to overcome or ameliorate one or more of the above
mentioned difficulties, or at least provide a useful alternative.

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Summary of the Invention

According to the present invention, there is provided a locking system for preventing
unauthorised access to, or removal of, coveted items, said system including:

35 (a) a sensor for receiving input from an external source;

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- (b) locking apparatus operable between open and closed conditions of use so as to respectively allow and prevent access to, or removal of, said coveted item;
- (c) one or more computer processors in communication with computer readable data storage including a plurality of executable instructions stored thereon which, when executed, cause the one or more processors to perform the steps of:
 - (i) receiving said receiving input from said sensor;
 - (ii) converting said input into a series of beats;
 - (iii) generating data representing time intervals between each beat in the series of beats;
 - (iv) identifying a shortest one of said time intervals and defining a set of classification intervals, each being a unique multiple of the shortest one of said time intervals;
 - (v) assigning each beat in the series with a corresponding one of said classification intervals based on a respective one of said time intervals;
 - (vi) generating a passcode by representing each beat in the series of beats with a number representing an associated classification interval;
 - (vii) comparing the passcode with a secret passcode stored in said data storage; and
 - (viii) if the passcode matches the secret passcode, then sending a signal to open the locking apparatus.

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Preferably, wherein the classification intervals are musical notes defined as multiples of said shortest time interval. Also, the step of assigning each beat in the series with a type of musical note preferably includes the steps of:

- (a) identifying a shortest one of the time intervals between each beat in the series of beats and classifying that interval as a semiquaver;
- (b) defining minims, crochets and quavers as multiples of the time interval for the semiquaver; and
- (c) classifying each beat in the series of beats as a minim, crotchet, quaver or a semiquaver.

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Preferably, the time interval for the notes are as follows:

- (a) quavers are two times that of the semiquavers;
- (b) crotchets are two times that of the quavers; and
- 5 (c) minims are two times that of the crotchets.

Preferably, the series of beats includes all beats recorded within a predetermined period of time. Advantageously, the predetermined period of time is in the range of 5 to 10 seconds.

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Preferably, the audio input from the external source includes one or more of:

- (a) finger or implement taps on or near the audio sensor;
- (b) hand clapping; and
- 15 (c) voice signals.

Brief Description of the Drawings

Preferred embodiments of the present invention are hereafter described, by way of
20 non-limiting example only, with reference to the accompanying drawing in which:

- Figure 1a is a front perspective view of a locking system;
- Figure 1b is a bottom perspective view of the locking system shown in Figure 1a;
- Figure 2 is a schematic diagram of the locking system shown in Figure 1a;
- 25 Figure 3 is a flow diagram showing steps performed by the locking system shown in Figure 1a;
- Figure 4 is a timing diagram showing a series of beats recorded by the locking system shown in Figure 1a;
- Figure 5 is a graphical representation of an input signal;
- 30 Figure 6 is a graphical representation of the signal shown in Figure 5 after it has been filtered;
- Figure 7 is a timing diagram showing beats of the signal shown in Figure 6;
- Figure 8 is a bottom perspective view an alternative locking system;
- Figure 9 is a top perspective view of the locking system shown in Figure 8; and
- 35 Figure 10 is a timing diagram showing a series of beats recorded by the locking

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system shown in Figure 8.

Detailed Description of Preferred Embodiments of the Invention

5 The locking system 10 shown in Figures 1a and 1b is used to prevent unauthorised access to, or removal of, coveted items. The locking system 10 preferably allows a user to open the lock 10 using musical melody in the form of:

- (a) taping on the lock 10;
- 10 (b) clapping near the lock 10; and/or
- (c) singing near the lock 10.

The musical melody can be set as a passcode and then later used to open the locking system 10. Using the locking system 10 in the manner obviates the need for
15 cumbersome input devices such as keyboards, touch screens, or any type of key press keys. The locking system 10 is applicable to any devices, and is especially well suited for small devices.

As particularly shown in Figure 2, the locking system 10 includes:
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- (a) a sensor 12 for receiving audio input from an external source;
- (b) locking apparatus 14 operable between open and closed conditions of use so as to respectively allow and prevent access to, or removal of, a coveted item; and
- 25 (c) one or more computer processors 16 in communication with computer readable data storage 18 including a plurality of executable instructions stored thereon in non transient memory.

The sensor 12 preferably includes a microphone 20 for receiving audio input from an
30 external source and an audio amplifier 22. The input to the audio sensor 12 includes, for example, one or more of:

- (a) finger or implement taps on or near the audio sensor 12;
- (b) sound from hand claps; and
- 35 (c) voice signals.

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Alternatively, the sensor 12 is a light sensor. The user is able to tap a melody using his finger on the light sensor 12. In doing so his finger will cover and uncover the sensor 12 and the system 10 will detect an input signal.

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In a further embodiment, the sensor 12 is a vibration sensor or an accelerometer. The sensor 12 is able to detect vibrations transmitted through the housing 28 as the user tap the melody thereon. Vibrations are detected through thresholds.

10 The locking apparatus 14 is operable between open and closed conditions of use so as to respectively allow and prevent access to, or removal of, a coveted item. As shown, the locking apparatus 10 is a padlock and the locking apparatus 14 includes a "U" shaped loop 24 coupled to a housing 28. A first arm 26a of the loop 24 is pivotally coupled to the housing 28 of the system 10. The coupling 30a securing the first arm
15 26a to the housing 28 facilitates axial rotation of the arm 26a in direction D_R . The coupling 30a also facilitates axial translation of the arm 26a in direction D_T between retracted and expanded conditions of use. The coupling 30a is preferably spring biased so as to resiliently urge the locking apparatus 14 towards an expanded condition of use.

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In the retracted condition of use shown in Figures 1a and 1b, the second arm 26b is seated in coupling 30b. The coupling 30b is operable to secure and release the second arm 26b from the housing 28.

25 In the open condition of use, the locking system 10 can be used to secure an item in position by threading the second arm 18a through a section of the item and then closing the loop 16 by seating the second arm 18b in the coupling 22b.

30 The above described features of the locking apparatus 14 and the housing 28 are generally known in the art and are not described here in further detail. It is envisaged that alternative configurations of the locking apparatus 14 could be used with the locking system 10.

35 The lock 10 includes an indicator 32 for showing the status of the lock. For example, the indicator 32 is a light emitting diode which receives a signal from the processor 16

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to illuminate when a correct input passcode is detected.

Use of the Locking System 10

5 With reference to Figure 3, the locking system 10 can be used to:

1. set up a passcode; and
2. open the locking apparatus 14.

10 The steps 100 performed by the locking system 10 to execute the above operations are described below in further detail with reference to the following musical notes:



A semibreve (also referred to as a whole note) is a note whose length is equal to four beats in 4/4 time.



A minim (also referred to as a half note) is a note played for half the duration of a semibreve (also referred to as a whole note). Its length is equal to two beats in 4/4 time.



A crotchet (also referred to as a quarter note) is played for a quarter of the duration of a semibreve. Its length is equal to one beat in 4/4 time.



A quaver (also referred to as an eighth note) is a musical note played for one eighth the duration of a semibreve.



A semiquaver (also referred to as a 16th note) is a note played for a sixteenth of a semibreve.

25 A dotted note is a note with a small dot written after it. In modern practice the first dot increases the duration of the basic note by half of its original value.

1. Set up Passcode

30 As above-mentioned, the one or more processors 16 are in communication with

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computer readable data storage 18 including, stored thereon in non-transient data storage, a plurality of executable instructions which, when executed, cause the one or more processors 16 to perform the steps of:

- 5 (a) polling, at step 102, the audio sensor 12 for an input signal from an external source;
- (b) if an input signal is received, then recording, at step 104, the input signal for a predetermined period of time;
- (c) filtering, at step 106, the input signal to identify a series of beats
10 occurring within the period of time;
- (d) generating, at step 108, data representing time intervals between the beats;
- (e) identifying, at step 110, a shortest one of the time intervals and classifying that interval as a semiquaver;
- 15 (f) defining, at step 112, minims, crochets and quavers as multiples of the time interval for the semiquaver;
- (g) classifying, at step 114, each beat as a minim, crotchet, quaver or a semiquaver;
- (h) digitally coding, at step 116, the classified beats so as to generate a
20 digital passcode for the input signal; and
- (i) if it is the first time that a pass code is entered, saving, at step 118, the digital passcode as a secret passcode in the storage 18.

25 The predetermined period of time is, for example, 10 seconds. However, any suitable period of time can be alternatively used.

 The step 106 of filtering the input signal removes noise and any unwanted audio frequencies and amplitudes. The filter is preferably a bandpass filter. The filtering process removes inherent noise and out of band noise.

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 The step 108 of generating data representing time intervals between the beats is performed by determining the time difference between when a beat starts and the next beat begins. The beats are detected by identifying the peaks in the filtered signal. Only the time difference information between each note is captured, where t is
35 the shortest duration between 2 notes. Alternatively, the beats could be identified by

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a threshold comparator output.

The step 112 of defining generating minimums, crochets and quavers includes the steps of defining:

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- (a) quavers as two times that of the semiquavers;
- (b) crotchets as two times that of the quavers; and
- (c) minims as two times that of the crotchets.

10 The above description of the locking system 10 is given with reference to the musical notes including semiquavers, quavers, crochets and minims. However, any suitable combination of musical notes can be used. These four were selected to provide a high level of security. That is, a suitable number of combinations for the passcode.

15 An example of the steps performed by the locking system 10 is shown in Figure 4 where only the rhythm beats of the input signal are retained and represented. As shown, the time "t" between beats, at step 108, is generated. The shortest time interval ($1/2 t$) is identified as a semiquaver. The time intervals for other notes are as multiples of the time interval for the semiquaver ($1/2t$):

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- (a) quavers = t;
- (b) crotchets = 2t; and
- (c) minims = 4t.

25 The processor 16 then classifies, at step 114, each beat in the sequence of beats as a minim, crotchet, quaver or a semiquaver:

- (a) t = quaver;
- (b) 3t = minim;
- 30 (c) 2t = crochet;
- (d) 2t = crochet;
- (e) t = quaver;
- (f) $\frac{1}{2} t$ = semiquaver; and
- (g) 6t = minim; and

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The processor 16 then digitally codes, at step 116, the classified sequence of beats so as to generate a digital passcode for the input signal:

	(a)	semiquaver	00
5	(b)	quaver	01
	(c)	crochet	10
	(d)	minim	11

In the example provided, the beats are digitized as follows:

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	(a)	t	=	quaver	=	01;
	(b)	3t	=	minim	=	11;
	(c)	2t	=	crochet	=	10;
	(d)	2t	=	crochet	=	10;
15	(e)	t	=	quaver	=	01;
	(f)	$\frac{1}{2} t$	=	semiquaver	=	00; and
	(g)	6t	=	minim	=	11.

Thus, the passcode is:

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01 11 10 10 01 00 11

Only audio input (tap, beat or sound) with the same rhythm or beat (the actual speed is irrelevant) will produce the same results, thus authenticating the user.

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The above-described steps are preferably performed multiple times for new passcode. The system 10 saves the multiple passcodes in data storage 18 for later use. For example, the system preferably records three versions of the passcode for later comparison. In doing so, the system 10 is able to build in some flexibility around passcode entry.

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In an alternative embodiment, the system 10 includes a passcode switch 19 for initiating recordal of a passcode to be entered by a user. As above-described, the coupling 30a facilitates axial translation of the arm 26a in direction D_T between retracted and expanded conditions of use. The coupling 30a is spring biased so as to

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resiliently urge the locking apparatus 14 towards an expanded condition of use. The above-mentioned switch 19 is actuated when the arm 26a is forced into the housing 28 direction D_T . Alternatively, an input signal can be used to indicate the start of a passcode.

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In a further embodiment, the above-described steps are performed when the system 10 is interfaced with a computer device, such as a smart phone. In this embodiment, the device is paired with the smartphone using standard communication protocols, such as BlueTooth™. The configuration of the system 10 is managed by an application program being executed on the smartphone. Such programs are known in the art. For example, the Noke lock (www.noke.com) uses an application program running on a smartphone to configure the lock with a passcode for a user or multiple users. This features of the Noke™ lock are suitable for use with the present invention and are not described here in further detail.

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The graph shown in Figure 5 shows an example a sound melody for a passcode captured through the microphone 20. The graph shows the amplitude of the signal picked up by the microphone 20 over time.

20 The graph shown in Figure 6 represents the sound melody shown in Figure 5 after the signal has been filtered by a bandpass filter. The filtering process removes inherent noise and out of band noise.

Figure 7 is a timing diagram representing the filtered signal shown in Figure 6 as a series of beats. The beats are detected by identifying the peaks in the filtered signal. Only the time difference information between each note is captured, where t is the shortest duration between 2 notes. Alternatively, the beats could be identified by a threshold comparator output.

30 **2. Open the Locking Apparatus 14**

As above-mentioned, the one or more processors 16 are in communication with computer readable data storage 18 including a plurality of executable instructions stored thereon which, when executed, cause the one or more processors to perform the steps of:

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- (a) polling, at step 102, the audio sensor 12 for an input signal from an external source;
- 5 (b) if an input signal is received, then recording, at step 104, the input signal for a predetermined period of time;
- (c) filtering, at step 106, the input signal to identify occurring beats within the period of time;
- (d) generating, at step 108, data representing time intervals between the beats;
- 10 (e) identifying, at step 110, a shortest one of the time intervals and classifying that interval as a semiquaver;
- (f) defining, at step 112, minims, crochets and quavers as multiples of the time interval for the semiquaver;
- (g) classifying, at step 114, each beat as a minim, crotchet, quaver or a semiquaver;
- 15 (h) digitally coding, at step 116, the classified beats so as to generate a digital passcode for the input signal;
- (i) if it is not the first time that a passcode is entered, comparing the passcode entered with the secret passcode saved in storage 18; and
- 20 (j) if the passcode entered matches the secret passcode, then sending a signal to open the locking apparatus 14.

On receipt of the signal, the coupling 30b of the locking apparatus 14 releases the second arm 26b and the loop 24 moves in direction D_T away from the body 28 so as to
 25 free second arm 26b.

In an alternative embodiment, the user initiates the above-described process by forcing the arm 26a into the housing 28 in direction D_T .

30 All the Audio filtering, peak detection and subsequent conversion to just time interval detection of the notes and subsequent comparison can be implemented using hardware design instead of a microprocessor. The hardware could be implemented using individual components such as comparators, shift registers, etc. It could also be design within a FPGA, EPLD or CPLD environment. It could even be employed within a
 35 DSP chip.

Alternative Locking System

The locking system 500 shown in Figures 8 and 9 is used to prevent unauthorised
5 access to, or removal of, coveted items. The locking system 500 preferably allows a
user to open the lock 500 using musical melody in the form of:

- (a) taping on the lock 500;
- (b) clapping near the lock 500; and/or
- 10 (c) singing near the lock 500.

The musical melody can be set as a passcode and then later used to open the locking
system 500. Using the locking system 500 in the manner obviates the need for
cumbersome input devices such as keyboards, touch screens, or any type of key press
15 keys. The locking system 500 is applicable to any devices, and is especially well
suited for small devices.

The locking system 500 shown in Figures 8 and 9 functions in an analogous manner to
that of the locking system 10. The locking system 500 includes many of the features
20 of the locking system 10. Like parts are referenced with like numbers.

As particularly shown in Figure 2, the locking system 500 includes:

- (a) a sensor 12 for receiving audio input from an external source;
- 25 (b) locking apparatus 14 operable between open and closed conditions of
use so as to respectively allow and prevent access to, or removal of, a
coveted item; and
- (c) one or more computer processors 16 in communication with computer
readable data storage 18 including a plurality of executable instructions
30 stored thereon in non transient memory.

As above-mentioned, the one or more processors 16 are in communication with
computer readable data storage 18 including, stored thereon in non-transient data
storage, a plurality of executable instructions which, when executed, cause the one or
35 more processors 16 to perform the steps of:

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- (a) receiving, at step 102, a start signal from the switch 19;
- (b) recording, at step 104, the input signal for a predetermined period of time;
- 5 (c) filtering, at step 106, the input signal to identify a series of beats occurring within the period of time;
- (d) generating, at step 108, data representing time intervals between the beats;
- 10 (e) identifying, at step 110, a shortest one of the time intervals and classifying that interval as a semiquaver;
- (f) defining, at step 112, musical notes as multiples of the time interval for the semiquaver;
- (g) classifying, at step 114, each beat as a one of the defined musical notes;
- 15 (h) digitally coding, at step 116, the classified beats so as to generate a digital passcode for the input signal; and
- (i) if it is the first time that a pass code is entered, saving, at step 118, the digital passcode as a secret passcode in the storage 18.

20 The predetermined period of time is, for example, 10 seconds. However, any suitable period of time can be alternatively used.

The step 106 of filtering the input signal removes noise and any unwanted audio frequencies and amplitudes. The filter is preferably a bandpass filter. The filtering
25 process removes inherent noise and out of band noise.

The step 108 of generating data representing time intervals between the beats is performed by determining the time difference between when a beat starts and the next beat begins. The beats are detected by identifying the peaks in the filtered
30 signal. Only the time difference information between each note is captured, where t is the shortest duration between 2 notes. Alternatively, the beats could be identified by a threshold comparator output.

The step 112 of defining musical notes, includes the steps of defining:
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- (a) quavers as two times that of the semiquavers;
- (b) crotchets as two times that of the quavers; and
- (c) minims as two times that of the crotchets.

5 The above description of the locking system 500 is given with reference to the musical notes including semiquavers, quavers, crotchets and minims. However, any suitable combination of musical notes can be used. These four were selected to provide a high level of security. That is, a suitable number of combinations for the passcode.

10 An example of the steps performed by the locking system 500 is shown in Figure 10 where only the rhythm beats of the input signal are retained and represented. As shown, the time "t" between beats, at step 108, is generated. The shortest time interval (t) is identified as a semiquaver. The time intervals for other notes are as multiples of the time interval for the semiquaver (t):

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- (a) quavers = 2t;
- (b) crotchets = 4t; and
- (c) minims = 8t.

20 The processor 16 then classifies, at step 114, each beat in the sequence of beats as a minim, crotchet, quaver or a semiquaver:

- (a) 2t = quaver;
- (b) 4t = crotchet;
- 25 (c) 3t = dotted quaver;
- (d) 3t = dotted quaver;
- (e) 2t = quaver;
- (f) t = semiquaver; and
- (g) 6t = dotted crotchet.

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A dotted note is a note with a small dot written after it. In modern practice the first dot increases the duration of the basic note by half of its original value.

The processor 16 then digitally codes, at step 116, the classified sequence of beats so
35 as to generate a digital passcode for the input signal:

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	(a)	t	=	semiquaver	=	000
	(b)	2t	=	quaver	=	001
	(c)	3t	=	dotted quaver	=	010
5	(d)	4t	=	crotchet	=	011
	(e)	5t	=		=	100
	(e)	6t	=	dotted crotchet	=	101

In the example provided, the beats are digitized as follows:

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	(a)	2t	=	quaver	=	001;
	(b)	4t	=	crotchet	=	011;
	(c)	3t	=	dotted quaver	=	010;
	(d)	3t	=	dotted crotchet	=	010;
15	(e)	2t	=	quaver	=	001;
	(f)	t	=	semiquaver	=	000; and
	(g)	6t	=	dotted crotchet	=	101.

Thus, the passcode is:

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001 011 010 010 001 000 101

Only audio input (tap, beat or sound) with the same rhythm or beat (the actual speed is irrelevant) will produce the same results, thus authenticating the user.

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Many modifications will be apparent to those skilled in the art without departing from the scope of the present invention.

In this specification and the claims that follow, unless stated otherwise, the word "comprise" and its variations, such as "comprises" and "comprising", imply the inclusion of a stated integer, step, or group of integers or steps, but not the exclusion of any other integer or step or group of integers or steps.

References in this specification to any prior publication, information derived from any said prior publication, or any known matter are not and should not be taken as an

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acknowledgement, admission or suggestion that said prior publication, or any information derived from this prior publication or known matter forms part of the common general knowledge in the field of endeavour to which the specification relates.

Claims Defining the Invention

1. A locking system for preventing unauthorised access to, or removal of, coveted items, said system including:
- 5 (a) a sensor for receiving input from an external source;
- (b) locking apparatus operable between open and closed conditions of use so as to respectively allow and prevent access to, or removal of, said coveted item;
- 10 (c) one or more computer processors in communication with computer readable data storage including a plurality of executable instructions stored thereon which, when executed, cause the one or more processors to perform the steps of:
- (i) receiving said receiving input from said sensor;
- (ii) converting said input into a series of beats;
- 15 (iii) generating data representing time intervals between each beat in the series of beats;
- (iv) identifying a shortest one of said time intervals and defining a set of classification intervals, each being a unique multiple of the shortest one of said time intervals;
- 20 (v) assigning each beat in the series with a corresponding one of said classification intervals based on a respective one of said time intervals;
- (vi) generating a passcode by representing each beat in the series of beats with a number representing an associated classification interval;
- 25 (vii) comparing the passcode with a secret passcode stored in said data storage; and
- (viii) if the passcode matches the secret passcode, then sending a signal to open the locking apparatus.
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2. The system claimed in claim 1, wherein the classification intervals are musical notes defined as multiples of said shortest time interval.
3. The system claimed in claim 2, wherein the step of assigning each beat in the
- 35 series with a corresponding one of said classification intervals includes the steps of:

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- (a) identifying a shortest one of the time intervals between each beat in the series of beats and classifying that interval as a semiquaver;
- (b) defining minims, crochets and quavers as multiples of the time interval for the semiquaver; and
- 5 (c) classifying each beat in the series of beats as a minim, crotchet, quaver or a semiquaver.

4. The system claimed in claim 2 or claim 3, wherein the time interval for the notes are as follows:
- 10 (a) quavers are two times that of the semiquavers;
 - (b) crochets are two times that of the quavers; and
 - (c) minims are two times that of the crochets.

5. The system claimed in any one of the preceding claims, wherein the series of
15 beats includes all beats recorded within a predetermined period of time.

6. The system claimed in claim 5, wherein the predetermined period of time is 10 seconds.

- 20 7. The system claimed in any one of claim 1 to 6, wherein the sensor is an audio sensor and the step of converting said input into basic beat melody includes upfront filtering of noise and any unwanted audio frequencies.

8. The system claimed in any one of claims 1 to 7, wherein the input from the
25 external source includes one or more of:
- (a) finger or implement taps on or near the audio sensor;
 - (b) hand clapping; and
 - (c) voice signals.

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