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(54) **METHOD AND SYSTEM FOR KEYLESS ENTRY**

(57) The present disclosure relates to a method performed by an entry system (1) for - prior to enabling a key device (2) keyless entry into a locked space (3) - establishing that the key device is within a vicinity of the locked space. The entry system determines (1001) a locked space stimulus signal (311), which locked space stimulus signal is derived from a sound and/or vibration signal detected by one or more sensors (31) associated with the locked space. The entry system moreover determines (1003) a key device stimulus signal (211), which key device stimulus signal is derived from a sound, motion and/or vibration signal detected by one or more sensors (21) associated with the key device. Furthermore, the entry system compares (1004) the locked space stimulus signal with the key device stimulus signal. The entry system further enables (1006) - when the locked space stimulus signal matches the key device stimulus signal - an unlocking of the locked space.

The disclosure also relates to an entry system in accordance with the foregoing.

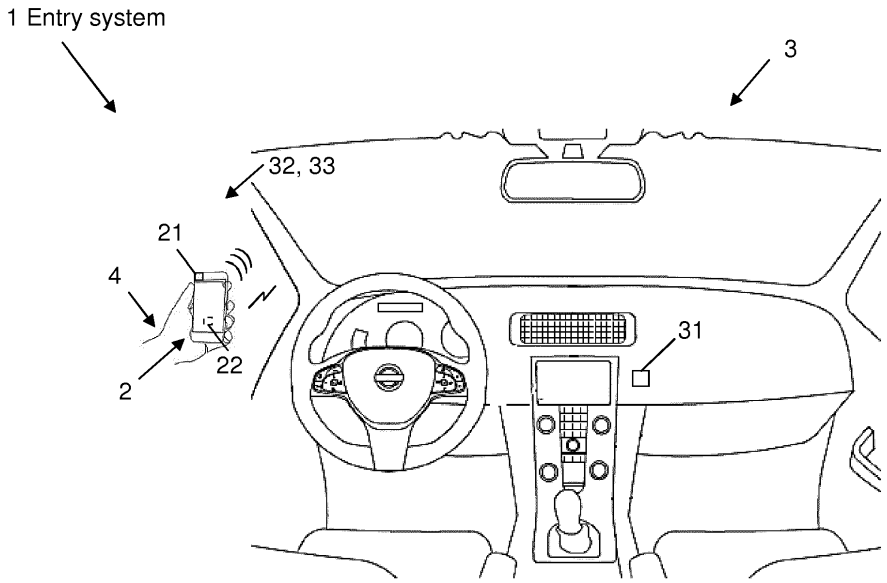

Fig. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to prior to enabling a key device keyless entry into a locked space, establishing that the key device is within a vicinity thereof.

BACKGROUND

[0002] Many of today's vehicles are equipped with a keyless entry system enabling access to the vehicle without using a traditional mechanical key. A vehicle equipped with a keyless entry system may be able to unlock its doors upon detecting a smart vehicle key such as an electronic key fob associated with the vehicle. There are mobile phone applications providing the functionality of an electronic key fob, thus enabling mobile phones to be used in place of electronic key fobs to control said unlocking of vehicle doors.

[0003] US 8,736,438 B1, for instance, relates to a computing device functioning as a vehicle key to control one or more functionalities of a vehicle. However, although the approach disclosed in US 8,736,438 B1 enables keyless entry by means of a computing device such as a mobile phone, there is still room for improvement when it comes to enabling secure keyless entry.

SUMMARY OF THE INVENTION

[0004] It is therefore an object of embodiments herein to provide an approach according to which accidental and/or malicious keyless entry into a locked space such as a vehicle, may be avoided.

[0005] According to a first aspect of embodiments herein, the object is achieved by a method performed by an entry system for - prior to enabling a key device keyless entry into a locked space - establishing that the key device is within a vicinity of the locked space. The entry system determines a locked space stimulus signal, which locked space stimulus signal is derived from a sound and/or vibration signal detected by one or more sensors associated with the locked space. The entry system moreover determines a key device stimulus signal, which key device stimulus signal is derived from a sound, motion and/or vibration signal detected by one or more sensors associated with the key device.

[0006] Furthermore, the entry system compares the locked space stimulus signal with the key device stimulus signal. The entry system further enables - when the locked space stimulus signal matches the key device stimulus signal - an unlocking of the locked space.

[0007] Thereby, an approach is provided according to which accidental and/or malicious keyless entry into a locked space such as a vehicle, may be avoided. That is, since a locked space stimulus signal is determined, which locked space stimulus signal is derived from a sound and/or vibration signal detected by one or more sensors associated with the locked space, a signal is established which is based on a sound and/or vibration pattern - e.g. a tapping sound - detected by at least a first sensor of the locked space. Furthermore, that is, since a key device stimulus signal is determined, which key device stimulus signal is derived from a sound, motion and/or vibration signal detected by one or more sensors associated with the key device, a signal is established which is based on a sound, movement and/or vibration pattern - e.g. from tapping - detected by at least a first sensor of the key device. Moreover, that is, since the locked space stimulus signal is compared with the key device stimulus signal, similarities between the signal detected by the locked space sensor(s) and the signal detected by the key device sensor(s) are analysed. Furthermore, since an unlocking of the locked space is enabled when the locked space stimulus signal matches the key device stimulus signal, entry into the locked space is enabled only if the locked space stimulus signal is determined to match the key device stimulus signal. Subsequently, entry into the locked space is enabled only if the signal detected by the locked space sensor(s) is considered to match the signal detected by the key device sensor(s), which implies that the key device sensor(s) has detected the same sound and/or vibration signal as the locked space sensor(s) has detected, and/or implies that the key device sensor(s) e.g. accelerometer has detected a motion signal correlating with the sound and/or vibration signal detected by the locked space sensor(s). This in turn implies that the key device is within a vicinity of the locked space. Accordingly, unlocking of the locked space is enabled only when the key device is in a vicinity of the locked space, which thus reduces the risk of accidental and/or malicious unlocking of the locked space from a distance.

[0008] For that reason, an approach is provided for avoiding accidental and/or malicious keyless entry into a locked space such as a vehicle.

[0009] The technical features and corresponding advantages of the above mentioned method will be discussed in further detail below.

[0010] By introducing a method performed by an entry system for - prior to enabling a key device keyless entry into a locked space - establishing that the key device is within a vicinity of the locked space, an approach is provided according to which accidental and/or malicious keyless entry into the locked space may be avoided. The "entry system" may fully or at least partly be comprised in, be integrated with and/or be connected to the locked space, for instance be distributed between one or more nodes, such as ECUs ("Electronic Control Units"). "Locked space" may refer to "locked vehicle, door, building, room, etc.", whereas the expression "keyless entry" may refer to "access without use of a traditional mechanical key". Furthermore, "keyless entry" may refer to "secure keyless entry" and/or active keyless entry", and moreover to "keyless entry through an electronic lock" and/or "keyless entry with support from electronic

remote control activated by said key device". Moreover, according to an example, the expression "keyless entry" may refer to the temporary disablement of an alarm, such as an anti-theft alarm, associated with the locked space, for example if repair and/or replacement work needs to be carried on the locked space without requiring entry into a part of the locked space, such as the replacement of a damaged wheel or punctured tyre, whereby "enabling an unlocking of the locked space" consequently refers to the temporary disablement of the alarm. The expression "prior to" enabling may refer to "before" enabling, whereas "enabling" may refer to "allowing" and/or "initiating". "Key device" may refer to "electronic key device", and furthermore to "portable and/or handheld key device". Moreover, the "key device" may for instance be represented by a smartphone and/or a smartwatch, or an equivalent and/or successor thereof. Furthermore, the "key device" may refer to a portable device adapted to be carried by an operator, establish a secure communication link with the entry system and/or a control unit associated therewith, run software and comprise one or more sensors. "Establishing" that the key device is within a vicinity may refer to "ensuring and/or determining" that the key device is within a vicinity, whereas the expression "a vicinity" may refer to "vicinity", "a close vicinity", "an arm's length", "1 meter", and/or "approximately 1 meter". According to an example, the expression "within a vicinity of said locked space" may refer to "within a standardized maximum distance from said locked space - or one or more sensors thereof - for allowing keyless entry". According to an example, the expression "for, prior to enabling a key device keyless entry into a locked space" may refer to "for, prior to enabling an operator associated with, in possession of and/or carrying a key device, keyless entry into a locked space". Moreover, according to another example, the expression "for, prior to enabling a key device keyless entry into a locked space, establishing that said key device is within a vicinity of said locked space" may refer to "for actively and securely enabling a key device keyless entry into a locked space".

[0011] Since the entry system determines a locked space stimulus signal, which locked space stimulus signal is derived from a sound and/or vibration signal detected by one or more sensors associated with the locked space, a signal is established which is based on a sound and/or vibration pattern - e.g. a tapping sound - detected by at least a first sensor of the locked space. "One or more sensors" may in this context refer to "one or more sound and/or vibration sensors and/or equivalents thereof", whereas "associated with the locked space" may refer to "of the locked space", "within the locked space" and/or "comprised in the locked space". The one or more sensors may be distributed within the locked space in any arbitrary manner considered appropriate for the implementation at hand. "Locked space" stimulus signal may refer to "interior" and/or "vehicle" stimulus signal, whereas locked space "stimulus" signal may refer to locked space "sound and/or vibration" signal. The expression sound and/or vibration "signal" may in this context refer to sound and/or vibration "sequence", "pattern", "envelope" and/or "stimulus", and detection thereof by the one or more locked space sensors may be accomplished as commonly known in the art. "Determining" a locked space stimulus signal may refer to "deriving" a locked space stimulus signal. The locked space stimulus signal "being derived from" a sound and/or vibration signal, may refer to the locked space stimulus signal "corresponding to" and/or "reflecting" a sound and/or vibration signal. Furthermore, the locked space stimulus signal being "derived" from a sound and/or vibration signal may refer to the locked space stimulus signal being "sampled" from a sound and/or vibration signal. In a similar manner, the expression from a sound and/or vibration signal "detected" by one or more sensors, may refer to from a sound and/or vibration signal "sampled" by one or more sensors. The sound and/or vibration signal and subsequently the corresponding locked space stimulus signal - and/or signatures thereof - may last an arbitrary duration of time, for instance from a few milliseconds up to several seconds or longer.

[0012] Since the entry system determines a key device stimulus signal, which key device stimulus signal is derived from a sound, motion and/or vibration signal detected by one or more sensors associated with the key device, a signal is established which is based on a sound, movement and/or vibration pattern - e.g. from tapping - detected by at least a first sensor of the key device. "One or more sensors" may in this context refer to "one or more sound sensors, motion sensors - such as accelerometers and/or gyroscopic sensors - and/or vibration sensors, and/or equivalents thereof", whereas "associated with the key device" may refer to "of the key device", "attached to the key device" and/or "comprised in the key device". "Key device" stimulus signal may refer to "exterior" stimulus signal, whereas key device "stimulus" signal may refer to key device "sound, motion and/or vibration" signal. The expression sound, motion and/or vibration "signal" may in this context refer to sound, motion and/or vibration "sequence", "pattern", "envelope" and/or "stimulus", and detection thereof by the one or more key device sensors may be accomplished as commonly known in the art. It is for instance commonly known that movement - e.g. back and forth - of a device - such as e.g. the key device - may be detected by a motion sensor - such as an accelerometer - comprised therein. "Determining" a key device stimulus signal may refer to "deriving" a key device stimulus signal. The key device stimulus signal "being derived from" a sound, motion and/or vibration signal may refer to the key device stimulus signal "corresponding to" and/or "reflecting" a sound, motion and/or vibration signal. Moreover, the expression "said key device stimulus signal being derived from a sound, motion and/or vibration signal detected by one or more sensors associated with said key device", may refer to "said key device stimulus signal being derived from a sound, mo-

tion and/or vibration signal detected by one or more sensors associated with said key device, said sound, motion and/or vibration signal being provided via a secure wireless communication link established between said key device and said entry system and/or a control unit associated therewith". Said secure communication link between the key device and the locked space and/or a control unit associated therewith, may be accomplished as commonly known in the art, for instance via Bluetooth or via an equivalent or successor thereof, or via any arbitrary short-range protocol. Furthermore, the key device stimulus signal being "derived" from a sound, motion and/or vibration signal may refer to the key device stimulus signal being "sampled" from a sound, motion and/or vibration signal. In a similar manner, the expression from a sound, motion and/or vibration signal "detected" by one or more sensors, may refer to from a sound, motion and/or vibration signal "sampled" by one or more sensors. The sound, motion and/or vibration signal and subsequently the corresponding key device stimulus signal - and/or signatures thereof - may last an arbitrary duration of time, for instance from a few milliseconds up to several seconds or longer.

[0013] Since the entry system compares the locked space stimulus signal with the key device stimulus signal, similarities and/or correlations between the signal detected by the locked space sensor(s) and the signal detected by the key device sensor(s) are analysed. "Comparing" may refer to "analysing similarities and/or correlations between", whereas "comparing said locked space stimulus signal with said key device stimulus signal" may refer to "comparing a signature and/or characteristics of said locked space stimulus signal with a signature and/or characteristics of said key device stimulus signal". Said "signature" may refer to "envelope". According to an example, the expression "comparing said locked space stimulus signal with said key device stimulus signal" may comprise "comparing said locked space stimulus signal with said key device stimulus signal, wherein when said locked space stimulus signal matches said key device stimulus signal, it is determined that said key devise is in a vicinity of said locked space". According to another example, the expression "comparing said locked space stimulus signal with said key device stimulus signal" may comprise "comparing said locked space stimulus signal with said key device stimulus signal, wherein when said locked space stimulus signal matches said key device stimulus signal, it is determined that said one or more key device sensors and said one or more locked space sensors have detected the same sound and/or vibration signal, and/or that said motion signal detected by said one or more key device sensors correlates with said sound and/or vibration signal detected by the one or more locked space sensors". "When" may refer to "if" and/or "provided that".

[0014] Since the entry system enables an unlocking of the locked space when the locked space stimulus signal matches the key device stimulus signal, entry into the locked space is enabled only if the locked space stimulus signal is determined to match the key device stimulus signal. Subsequently, entry into the locked space is enabled only if the signal detected by the locked space sensor(s) is considered to match the signal detected by the key device sensor(s), which implies that the key device sensor(s) has detected the same sound and/or vibration signal as the locked space sensor(s) has detected, and/or that the key device sensor(s) e.g. accelerometer has detected a motion signal correlating with the sound and/or vibration signal detected by the locked space sensor(s). This in turn implies that the key device is within a vicinity of the locked space. Accordingly, unlocking of the locked space is enabled only when the key device is in a vicinity of the locked space, which thus reduces the risk of accidental and/or malicious unlocking of the locked space from a distance. "Enabling" [...] an unlocking may refer to "initiating", "allowing" and/or "activating" [...] an unlocking, whereas "an unlocking" may refer to "unlock". Moreover, "unlocking of said locked space" may refer to "unlocking of one or more doors of said locked space" and/or "unlocking of one or more electronic locks of said locked space". The actual subsequent potential unlocking of the locked space may be accomplished as commonly known in the art. The expression "when said locked space stimulus signal matches said key device stimulus signal" may refer to "when a signature of and/or characteristics of said locked space stimulus signal matches a signature and/or characteristics of said key device stimulus signal". "When" may refer to "if" and/or "provided that", whereas "matches" may refer to "essentially matches", "to a predetermined extent matches", "correlates with" and/or "coincides with".

[0015] Optionally, comparing the locked space stimulus signal with the key device stimulus signal as described above, may comprise comparing a time signature and/or frequency domain signature of the locked space stimulus signal with a time signature and/or frequency domain signature of the key device stimulus signal. The enabling an unlocking of the locked space as described above then comprises enabling an unlocking of the locked space when the time signature and/or frequency domain signature of the locked space stimulus signal matches the time signature and/or frequency domain signature of the key device stimulus signal. Thereby, similarities and/or correlations may be established between the two signals, in view of time signatures and/or frequency domain signatures of said signals. "Matches" may refer to "essentially matches", "to a predetermined extent matches", "correlates with" and/or "coincides with".

[0016] Optionally, the actions described above may be performed at least partly on-board a locked vehicle, which locked vehicle then constitutes the locked space. The vehicle - which may be represented by a parked vehicle - may refer to any arbitrary manner or unmanned vehicle, for instance an engine-propelled or electrically-powered vehicle such as a car, truck, lorry, van, bus, aircraft, aeroplane, drone, vessel, boat etc., or a rail-

bound vehicle such as e.g. a train or tram. The vehicle may be adapted to support an unlocking of an electronic lock of one or more doors and/or trunk thereof, initiated by a key device associated therewith over e.g. a secure communication link, as commonly known in the art. "Performed" at least partly on-board a locked vehicle may refer to "performed by said entry system at least partly on-board a locked vehicle", whereas the expression "said locked vehicle constituting said locked space" may refer to "said locked vehicle representing said locked space".

[0017] Optionally, determining a locked space stimulus signal as described above may comprise determining a locked space stimulus signal, which locked space stimulus signal is derived from a sound and/or vibration signal emanating from tapping on an exterior surface of the locked space, detected by one or more sensors associated with the locked space. Similarly, determining a key device stimulus signal as described above may comprise determining a key device stimulus signal, which key device stimulus signal is derived from a sound, motion and/or vibration signal emanating from tapping on an exterior surface of the locked space, detected by one or more sensors associated with the key device. Thereby, the signal detected by the locked space sensor(s) and/or the signal detected by the key device sensor(s), is generated from tapping on e.g. a door and/or window of the locked space. That is, with the occurrence of tapping on an exterior of the locked space, a sound, motion and/or vibration signal is generated which sound and/or vibration signal may be detected by the locked space sensor(s). Correspondingly, said sound, motion and/or vibration signal may additionally be detected by the key device sensor(s) should the key device be in vicinity of the locked space - and/or the exterior thereof - and/or should the key device be positioned in e.g. a hand - or on a wrist - of an operator generating the tapping. The expression "emanating from" tapping may refer to "generated by", "generated from" and/or "resulting from" tapping, whereas "tapping" may refer to "knocking" and/or "tapping and/or knocking". Moreover, the expression "emanating from tapping on an exterior surface" may refer to "emanating from tapping by an operator in possession of said key device, on an exterior surface". "In possession of" may refer to "carrying" and/or associated with", whereas "an operator" may refer to "a person requesting keyless entry into said locked space and/or requesting an unlocking of said locked space". Tapping may for instance have been accomplished by the operator's hand, such as by means of the palm thereof, one or more fingers, and/or one or more knuckles, and/or by any arbitrary device carried by the operator. The expression "surface of said locked space" may refer to "surface of a door and/or window associated with said locked space".

[0018] Optionally, determining a locked space stimulus signal as described above may comprise determining a locked space stimulus signal, which locked space stimulus signal is derived from a sound and/or vibration signal emanating from tapping with the key device on an exterior surface of the locked space, detected by one or more sensors associated with the locked space. Similarly, determining a key device stimulus signal as described above may comprise determining a key device stimulus signal, which key device stimulus signal is derived from a sound, motion and/or vibration signal emanating from tapping with the key device on an exterior surface of the locked space, detected by one or more sensors associated with the key device. Thereby, the signal detected by the locked space sensor(s) and/or the signal detected by the key device sensor(s), is generated from tapping with the key device on e.g. a door and/or window of the locked space. That is, with the occurrence of tapping with the key device on an exterior of the locked space, a sound, motion and/or vibration signal is generated which sound and/or vibration signal may be detected by the locked space sensor(s). Correspondingly, said sound, motion and/or vibration signal may - with great certainty - be detected by the key device sensor(s). Tapping "with" the key device may refer to tapping "by means of" the key device, and may further include tapping "with a protective cover at least partly covering" the key device. Moreover, emanating from "tapping with said key device" on an exterior surface may refer to emanating from "tapping with said key device by an operator" on an exterior surface. As previously indicated, "operator" may refer to "a person requesting keyless entry into said locked space and/or requesting an unlocking of said locked space".

[0019] Optionally, determining a locked space stimulus signal as described above may comprise determining a locked space stimulus signal, which locked space stimulus signal is derived from a sound and/or vibration signal emanating from two or more instances of tapping on an exterior surface of the locked space, detected by one or more sensors associated with the locked space. Similarly, determining a key device stimulus signal as described above may comprise determining a key device stimulus signal, which key device stimulus signal is derived from a sound, motion and/or vibration signal emanating from two or more instances of tapping on an exterior surface of the locked space, detected by one or more sensors associated with the key device. Thereby, the signal detected by the locked space sensor(s) and/or the signal detected by the key device sensor(s), is generated from more than one tapping on e.g. a door and/or window of the locked space. That is, with the occurrence of two or more instances of tapping on an exterior of the locked space, a more extensive sound, motion and/or vibration signal is generated which sound and/or vibration signal may be detected by the locked space sensor(s). Correspondingly, said sound, motion and/or vibration signal may be detected by the key device sensor(s) should the key device be in vicinity of the locked space - and/or the exterior thereof - and/or should the key device sensor(s) be positioned in e.g. a hand - or on a wrist - of an operator generating the tapping. Emanating from two or more instances of "tapping" on an exterior surface may refer to

emanating from two or more instance of "tapping by an operator" on an exterior surface. As previously indicated, "operator" may refer to "a person requesting keyless entry into said locked space and/or requesting an unlocking of said locked space".

[0020] Optionally, the one or more locked space sensors may comprise at least two sensors. The entry system may then determine a direction from which the sound and/or vibration signal detected by the at least two locked space sensors originates. Enabling an unlocking of the locked space then further comprises enabling an unlocking when the direction originates from a predetermined section of the locked space. Thereby, in order to enable unlocking, in addition to the criteria that the locked space stimulus signal needs to match the key device stimulus signal, yet another criteria must be fulfilled, namely that the direction of the sound and/or vibration signal detected by the at least two locked space sensors needs to originate from a certain region of the locked space. That is, a sound and/or vibration signal intended for attempting an unlocking of the locked space, must originate from the predetermined section. Thus, should the locked space for instance be represented by a vehicle, then an operator in possession of the key device needs to e.g. tap - e.g. by means of the key device and/or e.g. two or more times - an exterior surface of the vehicle comprising the predetermined section. Accordingly, should the sound and/or vibration signal detected by the at least two locked space sensors originate from any other direction not within the predetermined section, then an unlocking of the locked space will not be enabled. That is, sound and/or vibrations signals assumed not intended for attempting an unlocking of the locked space, such as for instance arbitrary surrounding noise originating from directions not within the predetermined section, will not lead to unlocking of the locked space. The predetermined section may refer to a region at least partly comprising - and/or being close to e.g. within a few meters and/or centimetres of - an electronic lock of the locked space, one of the sensors and/or the entry system. Should the locked space be represented by a vehicle, then the predetermined section may refer to a region at least partly comprised in - and/or close to - a door, a door window, a windshield and/or chassis thereof, for instance on the driver's side and/or region of the vehicle. The size and/or shape of the predetermined section may be arbitrarily selected in view of the implementation at hand, for instance range from a few square centimetres up to several square meters. "When" the direction originates from a predetermined section may refer to "if" and/or "provided that" the direction originates from a predetermined section, and may in this context further refer to "when further" the direction originates from a predetermined section. "Originates" may refer to "comes".

[0021] According to an example, there is provided an entry system as discussed above,

wherein said ***enabling*** an unlocking of said locked space further comprises enabling an unlocking when said locked space stimulus signal matches a predetermined sound and/or vibration signal.

[0022] Thereby, in order to enable unlocking, in addition to the criteria that the locked space stimulus signal needs to match the key device stimulus signal, yet another criteria must be fulfilled, namely that the locked space stimulus signal needs to match a predetermined sound and/or vibration signal. Accordingly, yet another measure is provided in order to distinguish sound and/or vibration signals intended for attempting to unlock the locked space from other potential detected sound and/or vibration signals, and/or in order to implement an additional security measure. The predetermined sound and/or vibration signal may be arbitrarily selected, for instance personalized by an owner and/or operator of the locked space, e.g. vehicle. Said predetermined sound and/or vibration signal may for instance correspond to a predetermined number of stimulus, such as tapping, with a predetermined timing. The expression predetermined sound and/or vibration "signal" may refer to predetermined sound and/or vibration "sequence" and/ "pattern". Moreover, the expression "when said locked space stimulus signal matches a predetermined sound and/or vibration signal" may refer to "when a signature of and/or characteristics of said locked space stimulus signal matches a signature and/or characteristics of a predetermined sound and/or vibration signal". Furthermore, "matches" may refer to "essentially matches", "to a predetermined extent matches", "correlates with" and/or "coincides with". "When" the locked space stimulus signal matches a predetermined sound and/or vibration signal, may refer to "if" and/or "provided that" the locked space stimulus signal matches a predetermined sound and/or vibration signal, and may in this context further refer to "when further" the locked space stimulus signal matches a predetermined sound and/or vibration signal. Noise removal and/or any other signal processing and/or signal analyzing technique may be utilized before the locked space stimulus signal is compared with the predetermined sound and/or vibration signal.

[0023] According to an example, there is provided an entry system as discussed above, further adapted for:

determining a signal strength with which said key device communicates with the entry system;
wherein said ***enabling*** an unlocking of said locked space further comprises enabling an unlocking when said signal strength exceeds a predetermined minimum signal strength threshold.

[0024] Thereby, in order to enable unlocking, in addition to the criteria that the locked space stimulus signal needs to match the key device stimulus signal, yet another criteria must be fulfilled, namely that the signal strength associated with the secure communication link needs to reach up to a level considered sufficient. Ac-

cordingly, yet another measure is provided for establishing that the key device is in a vicinity of the locked space, with the assumption that a sufficient signal strength may be an indication of closeness. "Determining" a signal strength may refer to "measuring", "deriving" and/or "receiving" a signal strength, whereas the expression "communicates with the entry system" may refer to "communicates with an electronic control unit associated with the entry system" and/or "communicates with the locked space and/or vehicle". Moreover, "communicates with the entry system" may further refer to "communicates via a secure communication link with the entry system". "When" the signal strength exceeds a predetermined minimum signal strength threshold may refer to "if" and/or "provided that" the signal strength exceeds a predetermined minimum signal strength threshold, and may in this context further refer to "when further" the signal strength exceeds a predetermined minimum signal strength threshold. The minimum signal strength threshold may be arbitrarily set in view of the implementation at hand, and determination of the signal strength may be accomplished as commonly known in the art.

[0025] According to a second aspect of embodiments herein, the object is achieved by a method performed by an entry system adapted for - prior to enabling a key device keyless entry into a locked space - establishing that the key device is within a vicinity of the locked space. The entry system comprises a locked space determining unit adapted for determining a locked space stimulus signal, which locked space stimulus signal is derived from a sound and/or vibration signal detected by one or more sensors associated with the locked space. The entry system further comprises a key device determining unit adapted for determining a key device stimulus signal, which key device stimulus signal is derived from a sound, motion and/or vibration signal detected by one or more sensors associated with the key device. Moreover, the entry system comprises a comparing unit adapted for comparing the locked space stimulus signal with the key device stimulus signal. The entry system furthermore comprises an enabling unit adapted for enabling, when the locked space stimulus signal matches the key device stimulus signal, an unlocking of the locked space.

[0026] Optionally, the comparing unit is adapted for comparing a time signature and/or frequency domain signature of the locked space stimulus signal with a time signature and/or frequency domain signature of the key device stimulus signal. The enabling unit is then adapted for enabling, when the time signature and/or frequency domain signature of the locked space stimulus signal matches the time signature and/or frequency domain signature of the key device stimulus signal, an unlocking of the locked space.

[0027] Optionally, the entry system may be adapted to at least partly be provided on-board a locked vehicle, which locked vehicle constitutes the locked space.

[0028] Optionally, the locked space determining unit may be adapted for determining a locked space stimulus signal, which locked space stimulus signal is derived from a sound and/or vibration signal emanating from tapping on an exterior surface of the locked space, detected by one or more sensors associated with the locked space. Additionally or alternatively, optionally, the key device determining unit may be adapted for determining a key device stimulus signal, which key device stimulus signal is derived from a sound, motion and/or vibration signal emanating from tapping on an exterior surface the locked space, detected by one or more sensors associated with the key device.

[0029] Optionally, the locked space determining unit may be adapted for determining a locked space stimulus signal, which locked space stimulus signal is derived from a sound and/or vibration signal emanating from tapping with the key device on an exterior surface of the locked space, detected by one or more sensors associated with the locked space. Additionally or alternatively, optionally, the key device determining unit may be adapted for determining a key device stimulus signal, which key device stimulus signal is derived from a sound, motion and/or vibration signal emanating from tapping with the key device on an exterior surface of the locked space, detected by one or more sensors associated with the key device.

[0030] Optionally, the locked space determining unit may be adapted for determining a locked space stimulus signal, which locked space stimulus signal is derived from a sound and/or vibration signal emanating from two or more instances of tapping on an exterior surface of the locked space, detected by one or more sensors associated with the locked space. Additionally or alternatively, optionally, the key device determining unit may be adapted for determining a key device stimulus signal, which key device stimulus signal is derived from a sound, motion and/or vibration signal emanating from two or more instances of tapping on an exterior surface of the locked space, detected by one or more sensors associated with the key device.

[0031] Optionally, the one or more locked space sensors may comprise at least two sensors. The entry system may then further comprise a direction determining unit adapted for determining a direction from which the sound and/or vibration signal detected by the at least two locked space sensors originates. The enabling unit is then further adapted for enabling an unlocking, when further the direction originates from a predetermined section of the locked space.

[0032] According to an example, there may be provided an entry system as discussed above,

wherein said enabling unit further is adapted for enabling an unlocking when said locked space stimulus signal matches a predetermined sound and/or vibration signal.

[0033] According to another example, there may be provided an entry system as discussed above, further comprising:

a **signal strength determining unit** adapted for ***determining*** a signal strength with which said key device communicates with the entry system;
wherein said enabling unit then further is adapted for enabling an unlocking when said signal strength exceeds a predetermined minimum signal strength threshold.

[0034] Similar advantages as those mentioned in the foregoing in relation to the first aspect correspondingly apply to the second aspect, which is why these advantages are not further discussed.

[0035] According to a third aspect of embodiments herein, the object is achieved by a computer program product comprising a computer program containing computer program code means arranged to cause a computer or a processor to execute the steps of the entry system discussed above, stored on a computer-readable medium or a carrier wave.

[0036] Again, similar advantages as those mentioned in the foregoing in relation to the first aspect correspondingly apply to the third aspect, which is why these advantages are not further discussed.

[0037] According to a fourth aspect of embodiments herein, the object is achieved by:

A vehicle at least partly comprising an entry system as discussed above, for instance comprising said locked space determining unit, said optional direction determining unit, said key device determining unit, said comparing unit, said optional signal strength determining unit and/or said enabling unit. Yet again, similar advantages as those mentioned in the foregoing in relation to the first aspect correspondingly apply to the fourth aspect, which is why these advantages are not further discussed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] The various aspects of the non-limiting embodiments of the invention, including particular features and advantages, will be readily understood from the following detailed description and the accompanying drawings, in which:

Figure 1 illustrates a schematic overview of an exemplifying entry system according to embodiments of the disclosure;

Figure 2 is a schematic block diagram illustrating an exemplifying entry system according to embodiments of the disclosure;

Figure 3 illustrates an exemplifying diagram of signals detected in the locked space and by the key device according to embodiments of the disclosure;

Figure 4 is a flowchart depicting an exemplifying method for - prior to enabling a key device keyless entry into a locked space - establishing that the key device is within a vicinity of the locked space, according to embodiments of the disclosure; and

Figure 5 illustrates an exemplifying sequence diagram according to embodiments of the disclosure.

DETAILED DESCRIPTION

[0039] The non-limiting embodiments of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings, in which currently preferred embodiments of the disclosure are shown. This disclosure may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Like reference characters refer to like elements throughout. Dashed lines of some boxes in the figures indicate that these units or actions are optional and not mandatory.

[0040] In the following, according to embodiments herein which relate to - prior to enabling a key device keyless entry into a locked space - establishing that the key device is within a vicinity thereof, there will be disclosed an approach according to which accidental and/or malicious keyless entry into a locked space, such as a vehicle, may be avoided.

[0041] Referring now to the figures and **Figure 1** in particular, there is illustrated a schematic overview of an exemplifying **entry system 1** according to embodiments of the disclosure. The entry system 1 is adapted for - prior to enabling a **key device 2** keyless entry into a **locked space 3** - establishing that the key device 2 is within a vicinity of the locked space 3. The key device 2 is here represented by a smartphone, whereas the locked space 3 here is represented by a vehicle such as a passenger car. The key device 2 and the locked space 3 - here vehicle - are adapted to communicate via a secure communication link in a commonly known manner to subsequently - when conditions are fulfilled that will be explained further on - enable keyless entry into the locked space 3 - here vehicle - by means of the key device 2. The key device 2 comprises one or more **sensors 21**, here microphones. The key device 2 may further comprise an optional **app 22** which may assist an **operator 4** in a commonly known manner to communicate with the locked space 3 - here vehicle. Comprised in the locked space 3 - here vehicle - is one or more **sensors 31**, here microphones, which may be distributed as considered suitable for the implementation at hand. The locked space 3 - here vehicle - further comprises one or more exemplifying doors, which comprise electronic locks (not shown) which may be remotely unlocked as commonly known in the art. An **exterior surface** of the locked space 3 - here vehicle - is denoted **32**, and may refer to any arbitrary exterior surface thereof.

[0042] In the shown embodiment, it is illustrated how the operator 4 taps on the exterior surface 32 of the locked

space 3 - here vehicle - holding the key device 2 in his hand. The operator 4 here taps on the window on the driver's side, which in the shown embodiment represents an optional **predetermined section 33** of the locked space 3.

[0043] As further shown in **Figure 2**, which depicts a schematic block diagram illustrating an exemplifying entry system 1 according to embodiments of the disclosure, the entry system 1 comprises a **locked space determining unit 101**, an optional **direction determining unit 102**, a **key device determining unit 103**, a **comparing unit 104**, an optional signal **strength determining unit 105** and an **enabling unit 106**, all of which will be described in greater detail in conjunction with Figure 4. Furthermore, the embodiments herein for - prior to enabling a key device 2 keyless entry into a locked space 3 such as a vehicle - establishing that the key device 2 is within a vicinity of the locked space 3, may be implemented through one or more processors, such as a **processor 107**, here denoted CPU, together with computer program code for performing the functions and actions of the embodiments herein. Said program code may also be provided as a computer program product, for instance in the form of a data carrier carrying computer program code for performing the embodiments herein when being loaded into the entry system 1. One such carrier may be in the form of a CD ROM disc. It is however feasible with other data carriers such as a memory stick. The computer program code may furthermore be provided as pure program code on a server and downloaded to entry system 1. The entry system 1 may further comprise a **memory 108** comprising one or more memory units. The memory 108 may be arranged to be used to store e.g. information, and further to store data, configurations, schedulings, and applications, to perform the methods herein when being executed in the entry system 1.

[0044] Furthermore, the locked space determining unit 101, the optional direction determining unit 102, the key device determining unit 103, the comparing unit 104, the optional signal strength determining unit 105, the enabling unit 106, the optional processor 107 and/or the optional memory 108 may at least partly be comprised in the locked space 3 - here vehicle - for instance in one or more **nodes 109** thereof such as electronic control units (ECUs). Those skilled in the art will also appreciate that the locked space determining unit 101, the optional direction determining unit 102, the key device determining unit 103, the comparing unit 104, the optional signal strength determining unit 105 and/or the enabling unit 106 described above, and which will be described in more detail later on in this description, may refer to a combination of analog and digital circuits, and/or one or more processors configured with software and/or firmware, e.g. stored in a memory such as the memory 108, that when executed by the one or more processors such as the processor 107 perform as will be described in more detail in conjunction with Figure 4. One or more of these processors, as well as the other digital hardware, may be included in a single ASIC (Application-Specific Integrated Circuitry), or several processors and various digital hardware may be distributed among several separate components, whether individually packaged or assembled into a SoC (System-on-a-Chip).

[0045] **Figure 3** illustrates an exemplifying diagram of signals detected in the locked space 3 - here vehicle - and by the key device 2 according to embodiments of the disclosure. Here, the tap audio envelopes are generated from the operator 4 tapping four times on the exterior surface 32 of the locked space 3. Shown is a **locked space stimulus signal 311** and a **key device stimulus signal 211**, both of which will be described in greater detail in the following in conjunction with Figure 4.

[0046] **Figure 4** is a flowchart depicting an exemplifying method for - prior to enabling a key device 2 keyless entry into a locked space 3 - establishing that the key device 2 is within a vicinity of the locked space 3, according to embodiments of the disclosure. The exemplifying method, which may be continuously repeated, comprises the following actions discussed with support essentially from Figures 1-3. The actions may be taken in any suitable order, for instance may Actions 1001 and 1003 be performed simultaneously and/or in an alternate order.

Action 1001

[0047] In Action 1001, the entry system 1 determines - e.g. by means of the locked space determining unit 101 - a locked space stimulus signal 311. The locked space stimulus signal 311 is derived from a sound and/or vibration signal detected by one or more sensors 31 associated with the locked space 3. Thus, as shown with support at least from Figures 1-3, a signal 311 is established which is based on a sound and/or vibration pattern - e.g. a tapping sound - detected by at least a first sensor 31 of the locked space 3 - here vehicle.

[0048] Optionally, Action 1001 of determining a locked space stimulus signal 311 may comprise determining a locked space stimulus signal 311, which locked space stimulus signal 311 is derived from a sound and/or vibration signal emanating from tapping on an exterior surface 32 of the locked space 3, detected by one or more sensors 31 associated with the locked space 3. Thus, as shown with support at least from Figures 1 and 3, the signal 311 detected by the locked space sensor(s) 31 is generated from tapping on e.g. a door and/or window of the locked space 3. That is, with the occurrence of tapping on an exterior 32 of the locked space 3 - here vehicle - a sound and/or vibration signal is generated which may be detected by the locked space sensor(s) 31 - here sensor(s) on-board the vehicle.

[0049] Optionally, Action 1001 of determining a locked space stimulus signal 311 may comprise determining a locked space stimulus signal 311, which locked space stimulus signal 311 is derived from a sound and/or vibration signal emanating from tapping with the key device 2 on an exterior surface 32 of the locked space 3, detected

by one or more sensors 31 associated with the locked space 3. Thus, as shown with support at least from Figures 1 and 3, the signal 311 detected by the locked space sensor(s) 31 is generated from tapping with the key device 2 on e.g. a door and/or window of the locked space 3. That is, with the occurrence of tapping with the key device 2 on an exterior 32 of the locked space 3 - here vehicle - a sound and/or vibration signal is generated which may be detected by the locked space sensor(s) 31 - here sensor(s) on-board the vehicle.

[0050] Optionally, Action 1001 of determining a locked space stimulus signal 311 may comprise determining a locked space stimulus signal 311, which locked space stimulus signal 311 is derived from a sound and/or vibration signal emanating from two or more instances of tapping on an exterior surface 32 the locked space, detected by one or more sensors 31 associated with the locked space 3. Thus, as shown with support at least from Figures 1 and 3, the signal 311 detected by the locked space sensor(s) 31 is generated from more than one tapping on e.g. a door and/or window of the locked space 3. That is, with the occurrence of two or more instances of tapping on an exterior 32 of the locked space 3 - here vehicle - a more extensive sound and/or vibration signal is generated which may be detected by the locked space sensor(s) 31 - here sensor(s) on-board the vehicle; in Figure 3 there is illustrated four instances of tapping.

Action 1002

[0051] Optionally, the one or more locked space sensors 31 may comprise at least two sensors. Accordingly, in optional Action 1002, the entry system 1 may determine - e.g. by means of a direction determining unit 102 - a direction from which the sound and/or vibration signal detected by the at least two locked space sensors 31 originates.

Action 1003

[0052] In Action 1003, the entry system 1 determines - e.g. by means of the key device determining unit 103 - a key device stimulus signal 211. The key device stimulus signal 211 is derived from a sound, motion and/or vibration signal detected by one or more sensors 21 associated with the key device 2. Thus, as shown with support at least from Figures 1-3, a signal 211 is established which is based on a sound, motion and/or vibration pattern - here from tapping - detected by at least a first sensor 21 of the key device 2.

[0053] Optionally, Action 1003 of determining a key device stimulus signal 211 may comprise determining a key device stimulus signal 211, which key device stimulus signal 211 is derived from a sound, motion and/or vibration signal emanating from tapping on an exterior surface 32 of said locked space 3, detected by one or more sensors 21 associated with the key device 2. Thus, as shown with support at least from Figures 1 and 3, the signal 211 detected by the key device sensor(s) 21, is generated from tapping on e.g. a door and/or window of the locked space 3. That is, with the occurrence of tapping on an exterior 32 of the locked space 3 - here vehicle - a sound, motion and/or vibration signal is generated which may be detected by the key device sensor(s) 21 should the key device 2 be in vicinity of the locked space 3 - here vehicle - and/or the exterior 32 thereof, and/or should the key device sensor(s) 21 be positioned in e.g. a hand or on a wrist of an operator 4 doing the tapping.

[0054] Optionally, Action 1003 of determining a key device stimulus signal 211 may comprise determining a key device stimulus signal 211, which key device stimulus signal 211 is derived from a sound, motion and/or vibration signal emanating from tapping with the key device 2 on an exterior surface 32 of the locked space 3, detected by one or more sensors 21 associated with the key device 2. Thus, as shown with support at least from Figures 1 and 3, the signal 211 detected by the key device sensor(s) 21, is generated from tapping with the key device 2 on e.g. a door and/or window of the locked space 3. That is, with the occurrence of tapping with the key device 2 on an exterior 32 of the locked space 3 - here vehicle - a sound, motion and/or vibration signal is generated which is detected with great certainty by the key device sensor(s) 21.

[0055] Optionally, Action 1003 of determining a key device stimulus signal 211 may comprise determining a key device stimulus signal 211, which key device stimulus signal 211 is derived from a sound, motion and/or vibration signal emanating from two or more instances of tapping on an exterior surface 32 of the locked space 3, detected by one or more sensors 21 associated with the key device 2. Thus, as shown with support at least from Figures 1 and 3, the signal 211 detected by the key device sensor(s) 21 is generated from more than one tapping on e.g. a door and/or window of the locked space 3. That is, with the occurrence of two or more instances of tapping on an exterior 32 of the locked space 3 - here vehicle - a more extensive sound, motion and/or vibration signal is generated which potentially may be detected by the key device sensor(s) 21 should the key device 2 be in vicinity of the locked space 3 - here vehicle - and/or the exterior 32 thereof, and/or should the key device sensor(s) be positioned in e.g. a hand or on a wrist of an operator doing the tapping. In Figure 3, there is illustrated four instances of tapping.

Action 1004

[0056] In Action 1004, the entry system 1 compares - e.g. by means of the comparing unit 104 - the locked space stimulus signal 311 with the key device stimulus signal 211. Thus, as shown with support at least from Figures 1-3, similarities and/or correlations between the signal 311 detected by the locked space sensor(s) 31 - here the sensor(s) on-board the vehicle - and the signal 211 detected by the key device sensor(s) 21, are ana-

lysed.

[0057] Optionally, Action 1004 of comparing the locked space stimulus signal 311 with the key device stimulus signal 211, may comprise comparing a time signature and/or frequency domain signature of the locked space stimulus signal 311 with a time signature and/or frequency domain signature of the key device stimulus signal 211. Thus, as shown with support at least from Figure 3, similarities and/or correlations may be established between the two signals 311, 211, in view of time signatures and/or frequency domain signatures of the signals 311,211.

Action 1005

[0058] In optional Action 1005, the entry system 1 may determine - e.g. by means of the signal strength determining unit 105 - a signal strength with which the key device 2 communicates with the entry system 1.

Action 1006

[0059] In Action 1006, the entry system 1 enables - e.g. by means of the enabling unit 106 - when the locked space stimulus signal 311 matches the key device stimulus signal 211, an unlocking of the locked space 3. Thus, as shown with support at least from Figures 1 - 3, entry into the locked space 3 - here vehicle - is enabled only if the locked space stimulus signal 311 is determined to match the key device stimulus signal 211. Subsequently, entry into the locked space 3 - here vehicle - is enabled only if the signal detected by the locked space sensor(s) 31 - here the sensor(s) on-board the vehicle - is considered to match the signal detected by the key device sensor(s) 21, which implies that the key device sensor(s) 21 has detected the same sound and/or vibration signal as the locked space sensor(s) 31 has detected, and/or that the key device sensor(s) 21 has detected a motion signal - here the operator's 4 hand moving back and forth four times during tapping - which motion signal correlates with the sound and/or vibration signal detected by the locked space sensor(s) 31. This in turn implies that the key device 2 is within a vicinity of the locked space 3 - here vehicle. Accordingly, unlocking of the locked space 3 is enabled only when the key device 2 is in a vicinity of the locked space 3, which thus reduces the risk of accidental and/or malicious unlocking of the locked space - here vehicle - from a distance.

[0060] Optionally - following upon optional Action 1002 of determining a direction from which the sound and/or vibration signal detected by the at least two locked space sensors 31 originates - Action 1006 of enabling an unlocking of the locked space 3 may further comprise enabling an unlocking when further the direction originates from a predetermined section 33 of the locked space 3. Thus, as shown with support at least from Figure 1, in order to enable unlocking; in addition to the criteria that the locked space stimulus signal 311 needs to match the key device stimulus signal 211, yet another criteria must be fulfilled, namely that the direction of the sound and/or vibration signal detected by the at least two locked space sensors 31 needs to originate from a certain region 33 of the locked space 3. That is, a sound and/or vibration signal intended for attempting an unlocking of the locked space 3, must originate from the predetermined section 33. Thus, should the locked space 3 for instance be represented by a vehicle, then an operator 4 in possession of the key device 2 needs to e.g. tap - e.g. by means of the key device 2 and/or e.g. two or more times - an exterior surface 32 of the vehicle 3 comprising the predetermined section 33, which in the embodiment illustrated in Figure 1 is represented by the vehicle door window on the driver's side. Accordingly, should the sound and/or vibration signal detected by the at least two locked space sensors 31 - here the sensors on-board the vehicle - originate from any other direction not within the predetermined section 33, then an unlocking of the locked space 3 - here vehicle - will not be enabled. That is, sound and/or vibrations signals assumed not intended for attempting an unlocking of the locked space 3, such as for instance arbitrary surrounding noise originating from directions not within the predetermined section 33 - here window on the driver's side - will not lead to unlocking of the locked space 3 - here vehicle.

[0061] Optionally - following upon optional Action 1005 of determining a signal strength with which the key device 2 communicates with the entry system 1 - Action 1006 of enabling an unlocking of the locked space 3 may further comprise enabling an unlocking when further the signal strength exceeds a predetermined minimum signal strength threshold. Thus, as shown with support at least from Figure 1, in order to enable unlocking; in addition to the criteria that the locked space stimulus signal 311 needs to match the key device stimulus signal 211, yet another criteria must be fulfilled, namely that the signal strength associated with the secure communication link needs to reach up to a level considered sufficient. Accordingly, yet another measure is provided for establishing that the key device 2 is in a vicinity of the locked space 3 - here vehicle, with the assumption that a sufficient signal strength may be an indication of closeness.

[0062] Optionally - following upon Action 1004 of comparing, and should said comparing comprise comparing a time signature and/or frequency domain signature of the locked space stimulus signal 311 with a time signature and/or frequency domain signature of the key device stimulus signal 211 - then Action 1006 of enabling an unlocking of the locked space 3 may further comprise enabling, when the time signature and/or frequency domain signature of the locked space stimulus signal 311 matches the time signature and/or frequency domain signature of the key device stimulus signal 211, an unlocking of the locked space 3.

[0063] Optionally, Action 1006 of enabling unlocking of the locked space 3 may further comprise enabling an unlocking when the locked space stimulus signal 311

matches a predetermined sound and/or vibration signal. Thus, as shown with support at least from Figures 1 and 3, in order to enable unlocking; in addition to the criteria that the locked space stimulus signal 311 needs to match the key device stimulus signal 211, yet another criteria must be fulfilled, namely that the locked space stimulus signal 311 needs to match a predetermined sound and/or vibration signal. Accordingly, yet another measure is provided in order to distinguish sound and/or vibration signals intended for attempting to unlock the locked space 3 - here vehicle - from other potential detected sound and/or vibration signals, and/or in order to implement an additional security measure.

[0064] **Figure 5** illustrates an exemplifying sequence diagram according to embodiments of the disclosure. The term "user" indicated in Figure 5 refers to the operator 4 shown in Figure 1, whereas the term "PaK" refers to the node 109 shown in Figure 2.

[0065] The person skilled in the art realizes that the present disclosure by no means is limited to the preferred embodiments described above. On the contrary, many modifications and variations are possible within the scope of the appended claims. It should furthermore be noted that the drawings not necessarily are to scale and the dimensions of certain features may have been exaggerated for the sake of clarity. Emphasis is instead placed upon illustrating the principle of the embodiments herein. Additionally, in the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality.

Claims

1. A method performed by an entry system (1) for, prior to enabling a key device (2) keyless entry into a locked space (3), establishing that said key device (2) is within a vicinity of said locked space (3), said method comprising:

   determining (1001) a locked space stimulus signal (311), said locked space stimulus signal (311) being derived from a sound and/or vibration signal detected by one or more sensors (31) associated with said locked space (3);
   determining (1003) a key device stimulus signal (211), said key device stimulus signal (211) being derived from a sound, motion and/or vibration signal detected by one or more sensors (21) associated with said key device (2);
   comparing (1004) said locked space stimulus signal (311) with said key device stimulus signal (211); and
   enabling (1006), when said locked space stimulus signal (311) matches said key device stimulus signal (211), an unlocking of said locked space (3).

2. The method according to claim 1,

   wherein said ***comparing*** (1004) comprises:

   comparing a time signature and/or frequency domain signature of said locked space stimulus signal (311) with a time signature and/or frequency domain signature of said key device stimulus signal (211), and

   wherein said ***enabling*** (1006) an unlocking comprises:

   enabling, when said time signature and/or frequency domain signature of the locked space stimulus signal (311) matches said time signature and/or frequency domain signature of the key device stimulus signal (211), an unlocking of said locked space (3).

3. The method according to claim 1 or 2, wherein said method is performed at least partly on-board a locked vehicle, said vehicle constituting said locked space (3).

4. The method according to any one of claims 1-3,

   wherein said ***determining*** (1001) a locked space stimulus signal (311) comprises:

   determining a locked space stimulus signal (311), said locked space stimulus signal (311) being derived from a sound and/or vibration signal emanating from tapping on an exterior surface (32) of said locked space (3), detected by one or more sensors (31) associated with said locked space (3), and/or

   wherein said ***determining*** (1003) a key device stimulus signal (211) comprises:

   determining a key device stimulus signal (211), said key device stimulus signal (211) being derived from a sound, motion and/or vibration signal emanating from tapping on an exterior surface (32) of said locked space (3), detected by one or more sensors (21) associated with said key device (2).

5. The method according to claim 4,

   wherein said ***determining*** (1001) a locked space stimulus signal (311) comprises:

   determining a locked space stimulus signal (311), said locked space stimulus signal (311) being derived from a sound and/or vi-

bration signal emanating from tapping with said key device (2) on an exterior surface (32) of said locked space (3), detected by one or more sensors associated (31) with said locked space (3), and/or

wherein said ***determining*** (1003) a key device stimulus signal (211) comprises:

determining a key device stimulus signal (211), said key device stimulus signal (211) being derived from a sound, motion and/or vibration signal emanating from tapping with said key device (2) on an exterior surface (32) of said locked space (3), detected by one or more sensors (21) associated with said key device (2).

6. The method according to claim 4 or 5,

wherein said ***determining*** (1001) a locked space stimulus signal (311) comprises:

determining a locked space stimulus signal (311), said locked space stimulus signal (311) being derived from a sound and/or vibration signal emanating from two or more instances of tapping on an exterior surface (32) of said locked space (3), detected by one or more sensors (31) associated with said locked space (3), and/or

wherein said ***determining*** (1003) a key device stimulus signal (211) comprises:

determining a key device stimulus signal (211), said key device stimulus signal (211) being derived from a sound, motion and/or vibration signal emanating from two or more instances of tapping on an exterior surface (32) of said locked space (3), detected by one or more sensors (21) associated with said key device (2).

7. The method according to any one of claims 1-6, wherein said one or more locked space sensors (31) comprises at least two sensors, said method further comprising:

determining (1002) a direction from which said sound and/or vibration signal detected by the at least two locked space sensors (31) originates; wherein said ***enabling*** (1006) an unlocking of said locked space (3) further comprises enabling an unlocking when said direction originates from a predetermined section (33) of said locked space (3).

8. An **entry system** (1) adapted for, prior to enabling a key device (2) keyless entry into a locked space (3), establishing that said key device (2) is within a vicinity of said locked space (3), said entry system (1) comprising:

a **locked space determining unit** (101) adapted for ***determining*** (1001) a locked space stimulus signal (311), said locked space stimulus signal (311) being derived from a sound and/or vibration signal detected by one or more sensors (31) associated with said locked space (3);
a **key device determining unit** (103) adapted for ***determining*** (1003) a key device stimulus signal (211), said key device stimulus signal (211) being derived from a sound, motion and/or vibration signal detected by one or more sensors (21) associated with said key device (2);
a **comparing unit** (104) adapted for ***comparing*** (1004) said locked space stimulus signal (311) with said key device stimulus signal (211); and
an **enabling unit** (106) adapted for ***enabling*** (1006), when said locked space stimulus signal (311) matches said key device stimulus signal (211), an unlocking of said locked space (3).

9. The entry system (1) according to claim 8,

wherein said comparing unit (104) is adapted for:

comparing a time signature and/or frequency domain signature of said locked space stimulus signal (311) with a time signature and/or frequency domain signature of said key device stimulus signal (211), and

wherein said enabling unit (106) is adapted for:

enabling, when said time signature and/or frequency domain signature of the locked space stimulus signal (311) matches said time signature and/or frequency domain signature of the key device stimulus signal (211), an unlocking of said locked space (3).

10. The entry system (1) according to claim 8 or 9, wherein said entry system (1) is adapted to at least partly be provided on-board a locked vehicle, said locked vehicle constituting said locked space (3).

11. The entry system (1) according to any one of claims 8-10,

wherein said locked space determining unit (101) is adapted for:

determining a locked space stimulus signal

(311), said locked space stimulus signal (311) being derived from a sound and/or vibration signal emanating from tapping on an exterior surface (32) of said locked space (3), detected by one or more sensors (31) associated with said locked space (3), and/or

wherein said key device determining unit (103) is adapted for:

determining a key device stimulus signal (211), said key device stimulus signal (211) being derived from a sound, motion and/or vibration signal emanating from tapping on an exterior surface (32) of said locked space (3), detected by one or more sensors (21) associated with said key device (2).

12. The entry system (1) according to claim 11,

wherein said locked space determining unit (101) is adapted for:

determining a locked space stimulus signal (311), said locked space stimulus signal (311) being derived from a sound and/or vibration signal emanating from tapping with said key device (2) on an exterior surface (32) of said locked space (3), detected by one or more sensors (31) associated with said locked space (3), and/or

wherein said key device determining unit (103) is adapted for:

determining a key device stimulus signal (211), said key device stimulus signal (211) being derived from a sound, motion and/or vibration signal emanating from tapping with said key device (2) on an exterior surface (32) of said locked space (3), detected by one or more sensors (21) associated with said key device (2).

13. The entry system (1) according to claim 11 or 12,

wherein said locked space determining unit (101) is adapted for:

determining a locked space stimulus signal (311), said locked space stimulus signal (311) being derived from a sound and/or vibration signal emanating from two or more instances of tapping on an exterior surface (32) of said locked space (3), detected by one or more sensors (31) associated with said locked space (3), and/or

wherein said key device determining unit (103) is adapted for:

determining a key device stimulus signal (211), said key device stimulus signal (211) being derived from a sound, motion and/or vibration signal emanating from two or more instances of tapping on an exterior surface (32) of said locked space (3), detected by one or more sensors (21) associated with said key device (2).

14. The entry system (1) according to any one of claims 8-13, wherein said one or more locked space sensors (31) comprises at least two sensors, said entry system (1) further comprising:

a **direction determining unit** (102) adapted for ***determining*** (1002) a direction from which said sound and/or vibration signal detected by the at least two locked space sensors (31) originates; wherein said enabling unit (106) further is adapted for enabling an unlocking when said direction originates from a predetermined section (33) of said locked space (3).

15. A computer program product comprising a computer program containing computer program code means arranged to cause a computer or a processor to execute the steps of a method according to any of claims 1-7, stored on a computer-readable medium or a carrier wave.

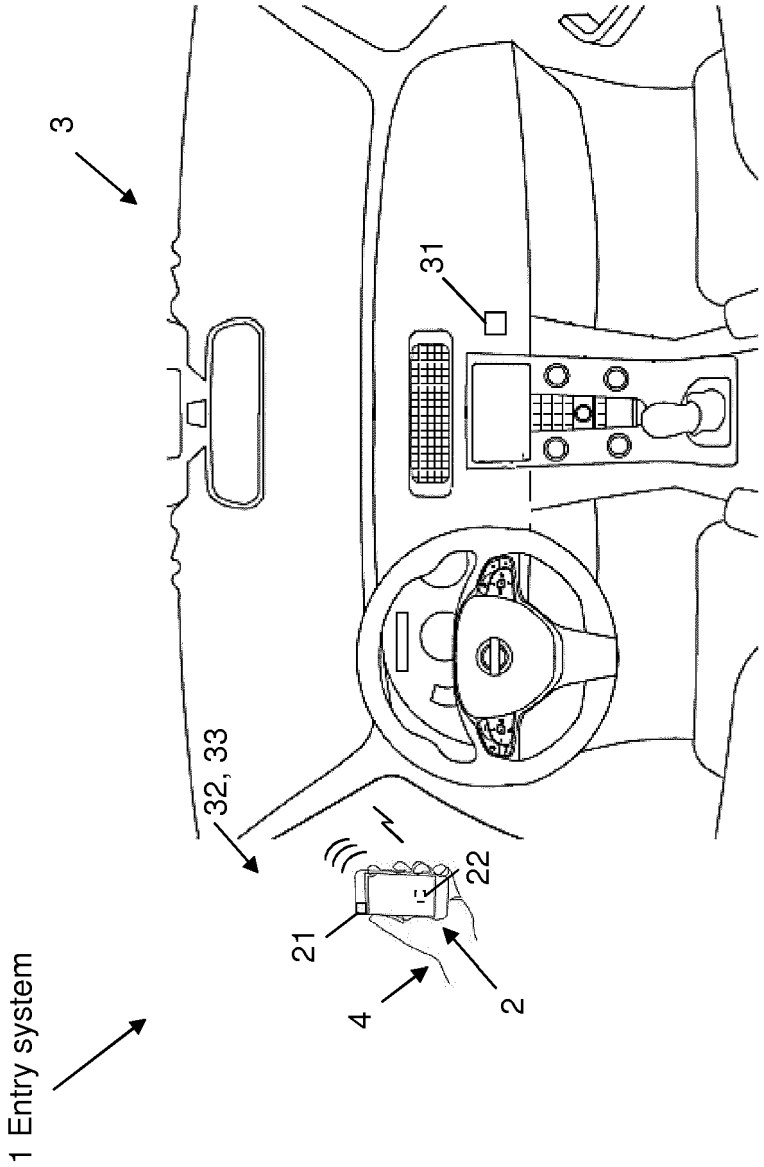

Fig. 1

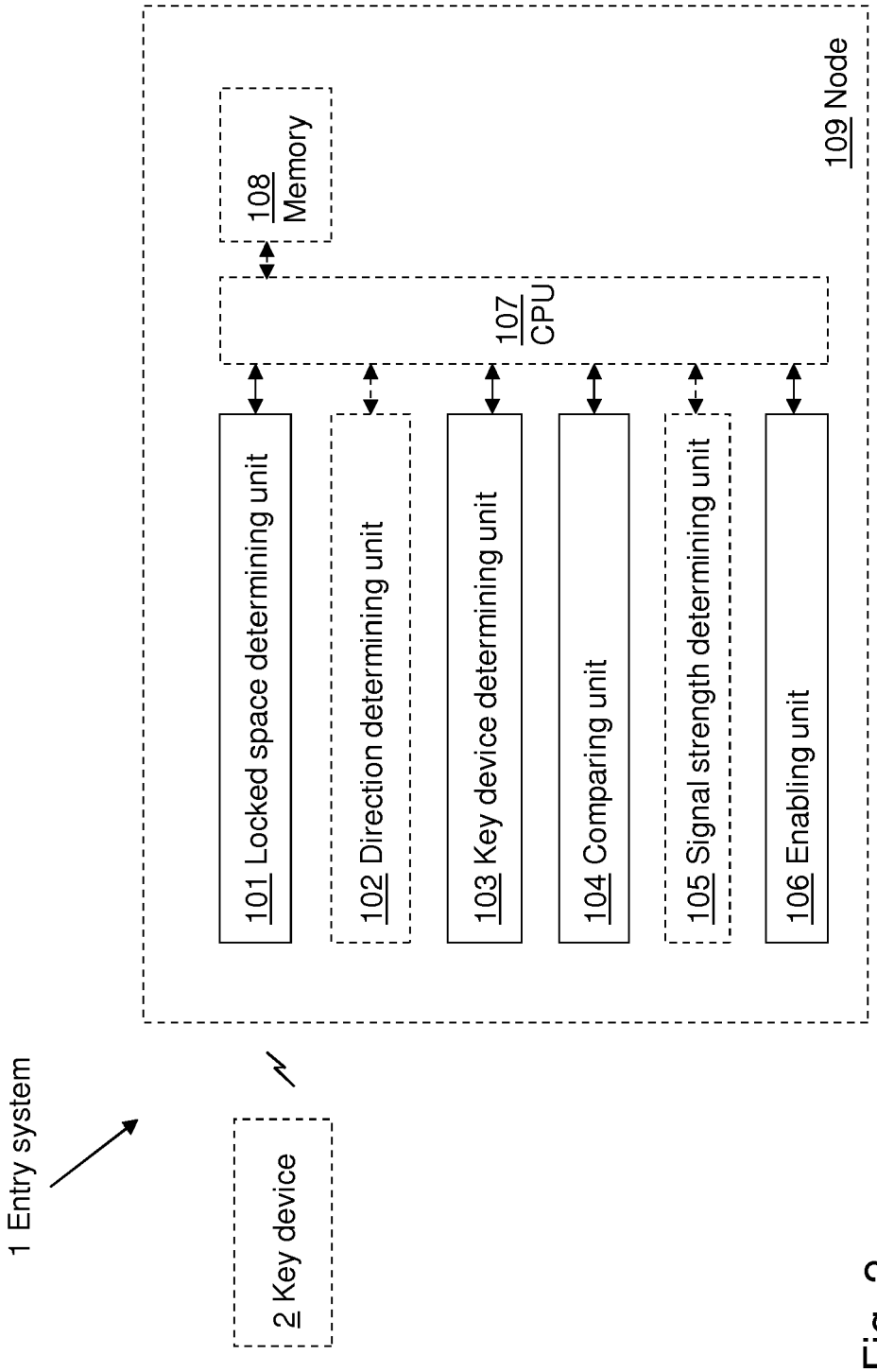
1 Entry system
2 Key device
109 Node
108 Memory
107 CPU
101 Locked space determining unit
102 Direction determining unit
103 Key device determining unit
104 Comparing unit
105 Signal strength determining unit
106 Enabling unit

Fig. 2

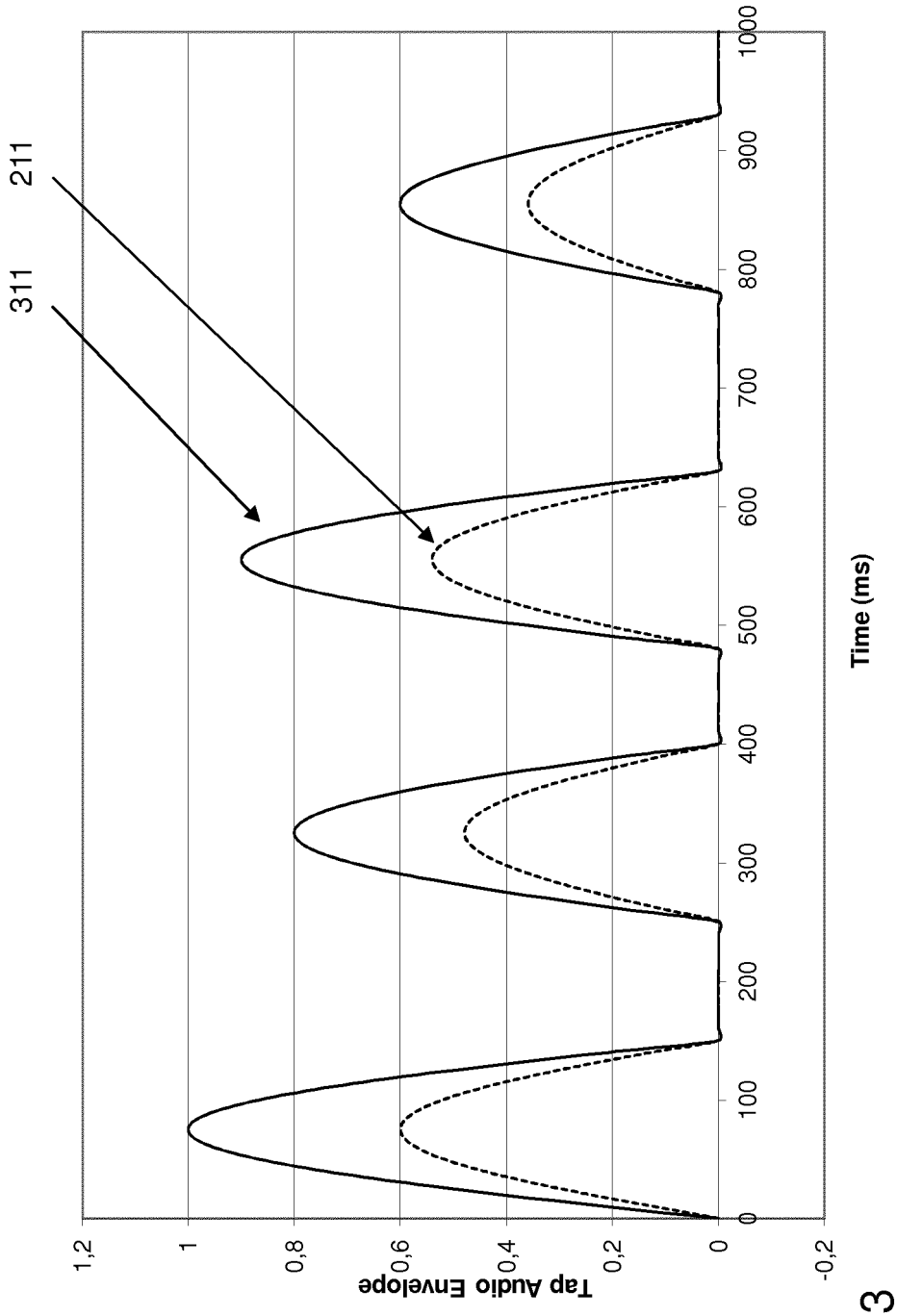
211
311
Tap Audio Envelope
1,2
1
0,8
0,6
0,4
0,2
0
-0,2
0
100
200
300
400
500
600
700
800
900
1000
Time (ms)

Fig. 3

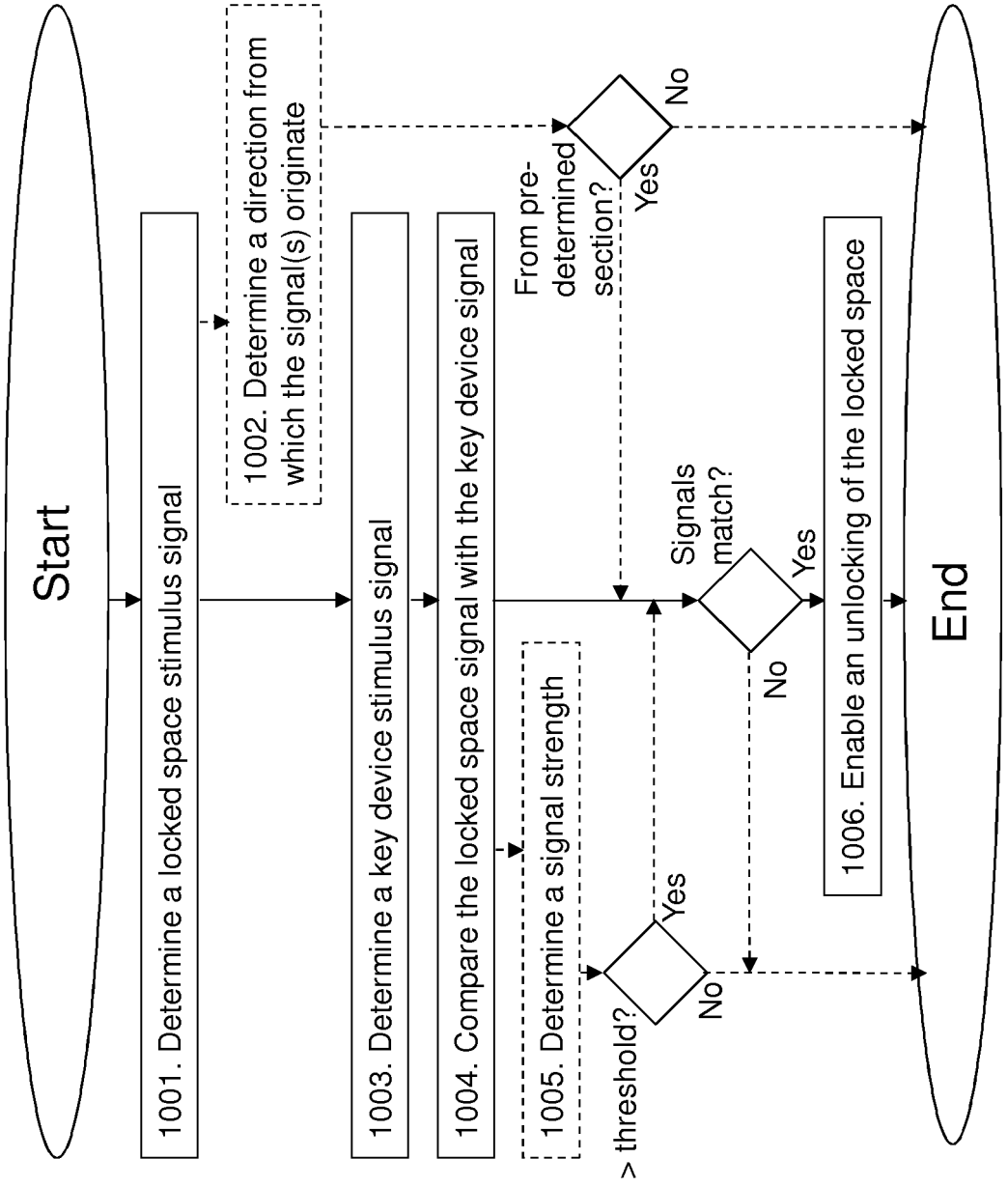
Start
1001. Determine a locked space stimulus signal
1002. Determine a direction from which the signal(s) originate
1003. Determine a key device stimulus signal
1004. Compare the locked space signal with the key device signal
1005. Determine a signal strength
> threshold?
Yes
No
Signals match?
Yes
No
From pre-determined section?
Yes
No
1006. Enable an unlocking of the locked space
End

Fig. 4

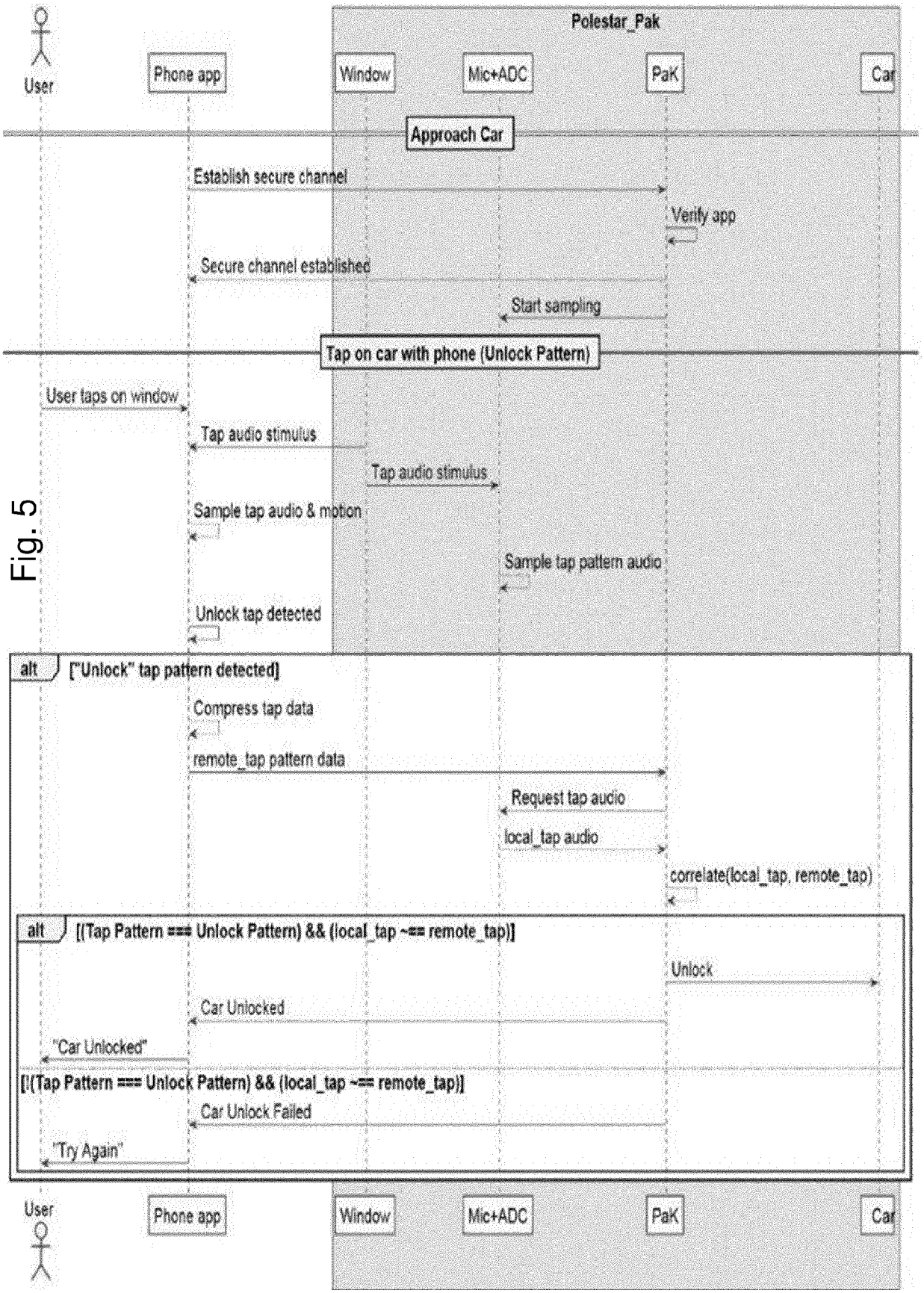
Polestar_Pak
User
Phone app
Window
Mic+ADC
PaK
Car
Approach Car
Establish secure channel
Verify app
Secure channel established
Start sampling
Tap on car with phone (Unlock Pattern)
User taps on window
Tap audio stimulus
Tap audio stimulus
Sample tap audio & motion
Sample tap pattern audio
Unlock tap detected
alt
["Unlock" tap pattern detected]
Compress tap data
remote_tap pattern data
Request tap audio
local_tap audio
correlate(local_tap, remote_tap)
alt
[(Tap Pattern === Unlock Pattern) && (local_tap ~== remote_tap)]
Unlock
Car Unlocked
"Car Unlocked"
[!(Tap Pattern === Unlock Pattern) && (local_tap ~== remote_tap)]
Car Unlock Failed
"Try Again"
User
Phone app
Window
Mic+ADC
PaK
Car

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 17 17 6868

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 December 2017	Ngandu, William

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