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## DEVICES AND METHODS FOR DETECTION OF CURRENTNESS OF DATA

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### Abstract

The present invention relates to a device (**30, 30'**) for enabling detection of currentness of data and to a device (**50, 50'**) for detection of currentness of data. The device for enabling detection of currentness of data is configured to obtain input data; generate entangled data by entangling the obtained input data with a continuously changing counter and thus changing the input data into the entangled data requiring untangling by use of the same counter to reveal the original input data; generate a hash by applying a hash function on the obtained input data; combine the entangled data and the hash into output data; and output the output data for transport over a transport medium.

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## Background/Summary

### FIELD OF THE INVENTION

[0001] The present invention relates to a first device for enabling detection of currentness of data, to a second device for detection of currentness of data, to a system comprising those devices, to corresponding methods and to a computer program for implementing said methods.

### BACKGROUND OF THE INVENTION

[0002] In multiple contexts data (e.g. physiological signals measured from a subject by as sensor) are transported over one or more transport media and there typically copied multiple times: The contents of a first copy are transported and another copy is created. Algorithms read the data and store their result (as copy of the result of the processing by the algorithm). At the end, the data may be converted into an image (e.g. an image illustrating the measured signals for display on a monitor). Hereby, the image is created, transported/copied and displayed at the end.

[0003] The situation when a computer or other electronic device freezes and stops responding is widely known. Such a freezing can be noticed at interaction with the device. However, by just “looking” at the device (e.g. a display screen), this situation can not necessarily be recognized. It is, however, be expected and assumed that any data that are present are “up to date”; currentness of data is, however, neither guaranteed nor detectable in an easy manner.

[0004] US 2019/0114733 A1 discloses systems and methods for display content currentness validation. An example method may include accessing, by a validation module executed by a processing device of a computer system, memory associated with a rendering module executed by a graphics processing unit of the computer system to verify that the rendering module renders up to date content on a display device of the computer system, retrieving, from the memory by the validation module, a timestamp embedded in content rendered by the rendering module on the display device, comparing, by the validation module, the timestamp to a current time of the computer system, and responsive to determining that the timestamp does not correspond to the current time of the computer system, determining that the content rendered by the rendering module on the display device is outdated. Further, a digital watermark may be embedded within the content prior to rendering it for display. Based on the watermark data, it may be determined that the rendered content is outdated, for instance by comparing the retrieved watermark against a current reference data.

### SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to provide a solution that enables (at a first device or method, such as a sender, source or creator of data) the detection of currentness of data and that performs (at a second device or method, such as a receiver, sink or processor of the data) the detection of currentness of data in order to improve the assurance that data are up to data so that it becomes easier to keep the confidence (i.e. the reliability of presentation of data).

[0006] In a first aspect of the present invention a device for enabling detection of currentness of data is presented, the device being configured to: [0007] obtain input data; [0008] generate entangled data by entangling the obtained input data with a continuously changing counter and thus changing the input data into the entangled data requiring untangling by use of the same counter to reveal the original input data; [0009] generate a hash by applying a hash function on the obtained input data; [0010] combine the entangled data and the hash into output data; and [0011] output the output data for transport over a transport medium.

[0012] In a further aspect of the present invention a device for detection of currentness of data is

presented, the device being configured to: [0013] obtain input data transported over a transport medium, the input data including entangled data and a hash; [0014] derive the entangled data and the hash from the obtained input data; [0015] generate untangled data by untangling the entangled data using a counter that has been used for entangling and thus changing the data into the entangled data requiring untangling by use of the same counter to reveal the original data; [0016] generate a check hash by applying a hash function on the untangled data; [0017] compare the generated check hash with the derived hash; and [0018] determine currentness and validity of the generated untangled data based on the comparison of the generated check hash with the derived hash.

[0019] In a further aspect of the present invention a system is presented comprising: [0020] a first device for enabling detection of currentness of data as disclosed herein; and [0021] a second device for detection of currentness of data as disclosed herein.

[0022] In yet further aspects of the present invention, there are provided corresponding methods, a computer program which comprises program code means for causing a computer to perform the steps of the methods disclosed herein when said computer program is carried out on a computer as well as a non-transitory computer-readable recording medium that stores therein a computer program product, which, when executed by a processor, causes the methods disclosed herein to be performed.

[0023] Preferred embodiments of the invention are defined in the dependent claims. It shall be understood that the claimed methods, system, computer program and medium have similar and/or identical preferred embodiments as the claimed devices, in particular as defined in the dependent claims and as disclosed herein.

[0024] The present invention is based on the idea to commonly use two different mechanisms:

[0025] i) The data that is to be transported (“the input data”) is entangled with a continuously changing counter, e.g. the current (real) time or a time-related counter. [0026] ii) The entangled data is combined with a check value (“the hash”).

The combined data is then outputted and transported over a transport medium, such as a wired or wireless connection. Since the counter (e.g. the time) continuously changes, the common result “entangled data” and “hash” will change as well.

[0027] The transported data are then used by first releasing them from entanglement by use of the counter that has been used for entanglement. If the transported data are “old” or delayed, they have been entangled (before transmission) with another counter value and are thus not usable. That the data are not correct is checked with the hash. Hence, it can be verified if the transported data is valid and usable, e.g. if the transported data are up to date and not delayed or copied (old) data.

[0028] For instance, in case of a physiological signal measured by a sensor from a subject it can be ensured that measured data that arrive e.g. at a patient monitor or computer and that are presented there to a caregiver or physician are up to date and correspond to the originally measured data, i.e. they are not delayed or are “old data frozen on the display”.

[0029] In the context of the present disclosure, “entangling” shall generally be understood broadly a modifying, interleaving, scrambling or otherwise changing the input data by use of the continuously changing counter. The input data are thus “corrupted” by the counter, i.e., the counter is not simply carried along with the input data, so that the entangled data are, as such, not carrying useful data any longer. Only the “detangling” (also called “untangling”) of the entangled data by use of the same counter reveals the original input data. Embedding a watermark within the input data is not understood as “entangling” since it does not change the input data by use of a continuously changing counter and the input data with an embedded watermark are still usable data that do not require untangling by use of the same counter.

[0030] “Counter” shall be understood broadly in the sense of any value or parameter or figure that is predictable, i.e., it shall be understood as a predictable changing value/parameter/figure that is continuously or regularly or irregularly changing. A pseudo-random value may hence be regarded as a counter as well.

[0031] In a preferred embodiment the device is configured to generate the entangled data by entangling the obtained input data by applying an exclusive OR operation on bits or values of the obtained input data and the continuously changing counter or by scrambling the obtained input data and the continuously changing counter. Thus, the entangling (and the corresponding detangling) operation can be rather simple, e.g. by using a binary XOR of the values of the input data in digital form. For instance, in an embodiment the order of the bits of the obtained input data can be scrambled, wherein the counter may be used to determine the order. More generally, a mathematical function may be applied that is reversible and that gets two pieces of information, i.e. the obtained input data and the counter. The amount of information (e.g. bits) can become larger. In this context, “reversible” means that the function can be reversed by use of the counter.

[0032] Preferably, the device is configured to generate the entangled data by entangling the obtained input data with the current time or a periodically changing value as continuously changing counter. Generally, any kind of counter can be used, as long as it is continuously (e.g. a regular or irregular intervals, at predetermined times, etc.) changing and known (e.g. set or agreed in advance, predetermined in a standard, communicated to the second device from the first device or another entity, etc.) to the devices so that they use the same counter. As mentioned, the counter does not need to count regularly, i.e. in the sense of changing at “equal time intervals”. In other embodiments, the counting of an event may be used, wherein an “event” may e.g. be to receive the input data, i.e. that something has been sent. Both sides typically know that as well. Further, in an embodiment any value, such as a real random number, may be used, but then this value needs to be transported, so that the data can be used. If not both sides know the counter (e.g. if an incorrect counter or an outdated counter value is used by the receiving side), this can be recognized according to the present invention as well,

[0033] The hash can generally be an arbitrary check value, hash function, a checksum, or parity. The kind of hash mainly determines the probability that is desired for detecting potential problems with respect to currentness of data.

[0034] In an embodiment the device is configured to generate the hash by applying a hash function on the obtained input data and the continuously changing counter. The hash is determined by both the obtained input data and the counter, i.e. the actual information and the counter value, as if the counter was part of the actual information. A simple hash function is e.g. a parity bit, i.e. an information whether the number of set bits in the information is even, here the bits in the input data and in the counter. The hash thus preferably includes the original data and the counter so that the hash value changes (due to the changes to the counter). Otherwise, there might be an indication that the data has not changed at all, which could easily be misused.

[0035] In the context of the present disclosure, to “combine the entangled data and the hash” shall generally be understood as any kind of combination as long as it is ensured that the two pieces of information can be brought together at the receiving end where they are accessed. A simple form of combination is to place one after the other. Another option is to transport entangled data and the hash in separate channels, for example in two messages.

[0036] In an embodiment the device is configured to output the hash with a lower data rate than the entangled data. This avoids an increase of the total data rate for outputting the data by the additional output of the hash in addition to the entangled data. In this case it is preferred that the hash is then generated from more input data to ensure that all input data are not only entangled but are “hashed” as well.

[0037] In an implementation the input data are obtained from a sensor configured to acquire measurement data from a subject. For instance, any kind of physiological data or vital sign (such as heart rate, SpO<sub>2</sub>, respiration rate, ECG signals, temperature, blood pressure, etc.) may be measured and transported to e.g. a patient monitor for processing and display. In such a scenario it is of utmost importance for patient's safety reasons that the data that are processed and displayed are up to date and not any old or (unintentionally) delayed data.

[0038] At the second device, e.g. a patient monitor in the scenario described above, currentness and validity of the generated untangled data is determined based on the comparison of the generated check hash with the derived hash. In particular, if the generated check hash is identical to the derived hash it is determined that the generated untangled data are current and valid, i.e. not unintentionally delayed or frozen.

[0039] In a system according to the present invention, in addition to the two devices explained above, a third device and a fourth device may be present, for instance to further process that data output by the second device. The third device is configured to generate a source image from the data (that have been checked for currentness by the second device) and to generate a secured image based on the source image by generating at least one secured image part, wherein the secured image part is generated by combining a source image part of the source image with a corresponding secure pattern. The fourth device is configured to display the secured image, to detect the security pattern from the secured image and to check the currentness of the detected security pattern. This provides for a reliable operating of displaying image data, by use of which it is ensured that current image data is displayed, i.e. that the displaying is done correctly.

[0040] This embodiment is based on the idea that additional information is added to image to be displayed, wherein the additional information may be invisible or nearly invisible when the image comprising the additional information is displayed, and that the additional information is used for monitoring the currentness of the displayed image, which, particularly, displayed contents of which may change over the time. The monitoring may be an independent process or part and is used to check integrity of changing image data, which may be critical. The additional information, particularly, the content of the additional information may be independent from the image, particularly, from the content visualized by the image. The additional information incorporated in the image may be changed over the time. Monitoring the displaying of the image may be done by checking the additional information with regard to additional information expected to be present in the displayed image. If the additional information has been changed or updated over the time, the expected additional information has to correspond to the last changed or updated additional information for approving a correct operating the displaying of the image. Further, the present invention may allow integrating changed image parts, which are retrieved or derived by other image sources, into the image to be displayed, wherein the other image sources are not the original image source of the image combined with additional information and may provide image data, which lacks, i.e. does not comprise additional information.

[0041] This embodiment is also called “screen freeze detection”, as disclosed in WO 2013/035015 A1. In this document, which is herein incorporated by reference, further embodiments are described that may be applied in the context of the present invention as well.

[0042] In a further embodiment one or more watchdogs may be used. When a system sees valid data, it can silence a watchdog. If the watchdog strikes, it can be deduced that the function is not processing valid data because it does not work at all or one channel does not transport the data. This option is better than just using a simple check whether a code is running, but it depends on the particular implementation whether it is applicable.

[0043] The system may be a patient monitoring system and at least the fourth device may be included or representing a patient monitor. Further, the first device may include or represent a data processor, and the second and third devices may include or represent an image generator.

[0044] In a particular implementation the system is configured to generate and display a stream of images comprising areas showing alarms or critical vital signs of a patient, wherein the images may change over time, and wherein the system comprises: [0045] a secured image generator configured to generate a stream of secured images based on a stream of source images comprising areas showing alarms or critical vital signs of a patient, by generating at least one secured image part in the source images, wherein the secured image part is generated by combining a part of the source image with a security pattern generated by the secured image generator, wherein said security

pattern is updated with time; [0046] a memory storage to store the secured images; and [0047] an observer storage configured to detect the security pattern from the secured image and to check the currentness of the detected security pattern by comparing the detected security pattern with an expected current security pattern.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

[0048] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter. In the following drawings

[0049] FIG. 1 shows a schematic diagram of a typical conventional implementation of a system for the transport and processing of measured data.

[0050] FIG. 2 shows a schematic diagram of an embodiment of a device for enabling detection of currentness of data according to the present invention.

[0051] FIG. 3 shows a flowchart illustrating an embodiment of a corresponding method performed by the device shown in FIG. 2.

[0052] FIG. 4 shows a schematic diagram of an embodiment of a device for detection of currentness of data according to the present invention.

[0053] FIG. 5 shows a flowchart illustrating an embodiment of a corresponding method performed by the device shown in FIG. 4.

[0054] FIG. 6 shows a schematic diagram of an embodiment of further optional devices in a system according to the present invention.

[0055] FIG. 7 shows a schematic diagram of an embodiment of a device for detection of currentness of data with additional watchdog according to the present invention.

[0056] FIG. 8 shows a schematic diagram of a system executing or supporting the monitoring of displaying image data according to an embodiment of the present invention.

### DETAILED DESCRIPTION OF EMBODIMENTS

[0057] A purpose of a display, e.g. a patient monitor, is to show critical data undistorted, without obscuring and in a timely manner. I.e., it is critical that certain parts of an image, e.g. areas showing alarms or critical vital signs, which may change over the time, are fully visible and updated regularly, i.e. are current and valid. Aspects of the present invention aim at ensuring, in certain applications, an effective, fast and safe operating of displaying of image data, which comprise information being relevant to safety, which may change over the time and/or displaying of which has to be up to date (i.e., if changes of at least one part of the image have occurred, these changes have to be visualized, displayed immediately).

[0058] FIG. 1 shows a schematic diagram of a typical conventional implementation of a system for the transport and processing of measured data. The system 1 comprises a generation unit 10 that obtains (e.g. receives or retrieves) data 20, e.g. measurement data of a sensor (e.g. a vital signs sensor such as a heart rate sensor or an ECG sensor), which is typically copied into a data copy 21. The data copy 21 is transported via a first transport way 11. The transported data copy 22 is provided to a processing unit 12 that may e.g. apply an algorithm to generate processed data 23. The processed data 23 is transported via a second transport way 13. The transported processed data 24 is provided to a presentation unit 14 that applies e.g. a user interface (UI) algorithm to generate an image of the data, such as a picture data 25 for presentation. These picture data 25 are transported via a third transport way 15. The transported picture 26 is provided to video hardware (HW) 16 for converting the received picture data into video signal for presentation as an image 27, e.g. on a screen of a computer or a patient monitor. Thus, in effect, the original data 20 is multiple times transported/copied and processed before the final information is presented to a user, in this example as an image on a screen.

[0059] In everyday life, situations where an electronic device, e.g. a computer or tablet, freezes and stops responding are generally known. This can usually be quickly noticed by user when the user interacts with the device. However, without interaction, and by just looking at the device (i.e., at the screen of the device) such a situation cannot easily be detected. Nevertheless, it is expected that the data presented on the screen is “up to date”, i.e. the presented data represented current data (rather than old, invalid or expired data).

[0060] The present invention aims at improving the “assurance” (i.e. a guarantee with high probability) that data provided to a user, e.g. presented on a screen (such as the image 27 in the system 1 shown in FIG. 1), are in fact current data so that it becomes easier to keep the confidence (reliability of presentation of data). This also applies to the case where standard components are used for processing and transport, where this assurance cannot (or can hardly) be achieved by checking the implementation.

[0061] Looking closer at the exemplary implementation of the system 1, several different problems (indicated by flashes in FIG. 1) may appear there.

[0062] A first potential problem is related to the transport way 15 and the presentation of the final data. Standard mechanisms are generally used when displaying the image 27, which are not necessarily safe. For instance, the copy operation/the transport may fail. For example, the image may be drawn into a texture that is still being drawn by a 3D system. If the 3D system fails/crashes, it can be continued to draw into the texture, but nothing will appear. As another example, the image may be written to one memory but read from another memory (e.g. a previous version, for example by double buffering and triple buffering).

[0063] A second potential problem is related to the presentation unit 14. The drawing process itself may be executed. If nothing is drawn at all, e.g. if the drawing process fails, the result is also shown frozen.

[0064] A third potential problem is related to the first and second transport ways 11 and 13. The data itself is repeatedly read on its way from memories into which the information was written. Here the problem can occur that the data is read from the wrong memory or the transport into this memory was disturbed (e.g. it does not take place at all, or even an old transport is repeated instead of being executed again).

[0065] A fourth potential problem is related to the generation unit 10 and the processing unit 12. The data is generated at some point, either by being measured, or by being modified, merged, or converted by an algorithm. These processes can fail so that no new data are output at all.

[0066] To address (and overcome) the first and second problems a solution as disclosed in WO 2013/035015 A1 (also called “screen freeze detection”) may be applied. It relies on the fact that the transport of the data up to the “drawing” has worked, and checks (only) that the drawing process takes place and the result of it also arrives in the final memory.

[0067] The third and fourth problems arise in particular when standard solutions, such as database systems, are used. The problem with the wrong memory may be solved by the type of data and can immediately recognized as obviously wrong. For instance, a heart rate with the value “2147483648” can be easily recognized as “something is wrong here”. But if there are many data in the memory, which are also similar, this is no longer typically the case. Such systems often do not have their own watchdog mechanism. They do not independently guarantee whether they are running or not. Since they can often be very complex, it is not practical or completely impossible to check the validity and currentness of the data as well as their generation and transport. In addition, it is a common optimization to look at the content when copying. If copied content is identical to the old content, it generally appears that nothing has to be done. However, older data may be used longer than intended and may thus no longer reflect the correct current data. Further, caching strategies meant to handle volumes of data are simply a potential source of error for these situations. Optimizing onto “data rarely changes” is counterproductive here, but sometimes simply exists.

[0068] Aspects of the present invention thus seeks to narrow down the third and fourth problems and to get an end to end solution that enables the detection of the currentness of data despite one or more of the potential problems illustrated above may appear.

[0069] FIG. 2 shows a schematic diagram of an embodiment of a device **30** for enabling detection of currentness of data according to the present invention. FIG. 3 shows a flowchart illustrating an embodiment of a corresponding method **100** performed by the device **30**.

[0070] The device **30** (herein also called first device) obtains (received or receives) input data **31** (step **S10**), such as measurement data of a sensor. Subsequently (step **S11**), it generates entangled data **32** by entangling the obtained input data **31** with a continuously changing counter **33**, such as the current time or another time counter. Further (step **S12**), it generates a hash **34** by applying a hash function on the obtained input data, e.g. by applying a parity function that generates parities from the obtained input data. The entangled data **32** and the hash **34** are combined into output data **35** that are outputted for transport over a transport medium **40**. Hereby, in an embodiment saving data rate, the hash may be outputted with a lower data rate than the entangled data. It shall be noted that steps **S11** and **S12**, although they are shown in a consecutive order in FIG. 3, they may be carried out parallel or in a different consecutive order (i.e., step **11** may be carried out after step **S12**).

[0071] The device **30** may represent, in the system **1** shown in FIG. 1, the generation unit **10** and/or the processing unit **12**. It can be implemented as processor or computer, as hard- and/or software. For instance, in an embodiment it may be implemented as a programmed processor. The method **100** may e.g. be implemented as computer program running on a computer or processor. The input data **31** may be obtained directly from the sensor or from a buffer or memory through a wireless or wired transmission, e.g. via a measurement cable or a Bluetooth connection. The transport medium **40** may be a wireless or wired transmission medium as well.

[0072] According to an embodiment of the present invention known mechanisms may be used for data transport (e.g. with a database system) and data entangling, e.g. by interleaving the input data with the current time (as counter) and supplemented with a check value (as hash). The entangling (e.g. interleaving) of the input data with time may be rather simple, e.g. by use of a binary XOR of the values of the input data in digital form.

[0073] The check value may be an arbitrary hash function, a checksum, or just a parity bit. Generally, it depends on what probabilities shall be used to detect problems. The hash function includes the original data and may optionally include the counter (e.g. the current time) as well. Since the counter (e.g. the time) always changes, the common result, i.e. the entangled data and the hash, will change as well, so that typically “no change optimizations” in the transport are already leveraged.

[0074] FIG. 4 shows a schematic diagram of an embodiment of a device **50** for detection of currentness of data according to the present invention. FIG. 5 shows a flowchart illustrating an embodiment of a corresponding method **200** performed by the device **50**.

[0075] The device **50** (herein also called second device) obtains (step **S20**) input data **51** transported over the transport medium **40** (or another transport medium). The input data **51** include entangled data **52** and a hash **53**, i.e. the input data **51** should correspond to the output data **35**, but have been transported over the transport medium, which may have caused some problems. Further problems may have been caused by the output of the output data **35** by the device **30** and the reception of the input data **51** by the device **50**. Subsequently (step **S21**), the entangled data **52** and the hash **53** are derived from the obtained input data **51**. Untangled data **54** are generated (step **S22**) by untangling the entangled data **52** using a counter **55** that has been used for entangling the data (by the device **30**), e.g. by using the current time or a time counter. A check hash **56** is generated by applying a hash function on the untangled data **54** (step **S23**), which is then compared with the derived hash **53**. Based on the comparison of the generated check hash **56** with the derived hash **53** currentness and validity of the generated untangled data **54** is then determined (step **S24**), i.e., it is



determined if the generated untangled data **54** are current data (rather than old/expired data) and if the generated untangled data **54** are valid (i.e., have not been manipulated or corrupted in any way). For instance, a flag **57** indicating if the untangled data is valid may be generated.

[0076] Thus, in order for the data to be used, it must first be released from entanglement. The counter (e.g. the time) is necessary for this purpose. Without it, the data is not usable, and thus the problem of delays, etc., is shown. If the data are “old”, they are entangled (e.g. interleaved) with a different counter value (e.g. a different time value) and thus not usable. The hash value is used to check if the data is correct or not so that finally a “data is valid and usable” information may be provided as output by the device **50**, e.g. to an algorithm for further processing of the untangled data or a transport medium for further transport.

[0077] The newly created data **61**, i.e. the output of the algorithm **60** may then be repackaged in the same way as illustrated in FIGS. **2** and **3** by another device **30'** that may be configured in the same or similar way as the device **30**. It may be entangled with a counter, complemented with a hash and then outputted to another transport medium **70**.

[0078] The devices **50** and **30'** and the method **200** (as well as the method performed by the device **30'**) may generally be implemented in the same or similar manner as the device **30** and the method **100**, e.g. by software and/or hardware, e.g. as programmed processor. The devices **50** and **30'** as well as the (optional) algorithm **60** (e.g. running on a processor) may be represent a system **2** that may be implemented as a common device (e.g. a common processor or computer. Referring to FIG. **1**, the system **2** may e.g. represent the processing unit **12** and/or the presentation unit **14**.

[0079] It shall be noted that the counter (**55** in FIG. **4**) that is provided to the different units in this embodiment may always be the same counter in an embodiment. In other embodiments different counters may be used, in particular the counter used by device **30'** may be different from the counter used by device **50**. If there is more than one source for the algorithm **60**, it is preferred that different counters are used since each source of an algorithm may use its own counter.

[0080] FIG. **6** shows a schematic diagram of further optional components of a system **3** according to the present invention. These components may include a third device **80** and a fourth device **120**. The third device **80** may be coupled to the system **2** and receive data that are transported via the transport medium **70**.

[0081] The third device **80** is configured to generate a source image from the data and to generate a secured image based on the source image by generating at least one secured image part, wherein the secured image part is generated by combining a source image part of the source image with a corresponding secure pattern. In more detail, the third device **80** comprises a device **50'** for detection of currentness of data according to the present invention, that is identical or similar to the device **50** shown in FIG. **4**. It processes the obtained input data **83** (including entangled data **81** and a hash **82**) to generate untangled data **84** and a validity flag **85**. These data **84** and **85** and the counter **91** (which is generally a different counter than the counter **33** or **55** shown in FIGS. **2** and **4**) are provided to a pattern generator **86** and a UI algorithm **87** for generating a picture **88** (the secured image) including a secure pattern **89** (e.g. a digital watermark or other hidden information) and an image **90** representing the untangled data (e.g. a graph or number showing the currently measured sensor value, e.g. the current heart rate or SpO2 value).

[0082] Thus, the input data is released from the entanglement and checked. Subsequently, the data is converted into an image. The image contains a secure pattern part and the actual, data-showing image. Hereby, for at least a part of the source image (or the complete source image) that is generated from the untangled data **84** a secured image part is generated, wherein the secured image part is generated by combining a source image part of the source image with a corresponding secure pattern. Further details and embodiments how the secured image is generated, which may be applied by the third device **80**, can be found in WO 2013/035015 A1.

[0083] The fourth device **120** is configured to display the secured image, to detect the security pattern from the secured image and to check the currentness of the detected security pattern. This

device **110** may be implemented in a way as disclosed in WO 2013/035015 A1 as well. The picture **88** generated by the third device **80** may be transported over a transport medium **110** to the fourth device **120** that obtains the transported picture **121** including the secure pattern **122** and the image **123**. In parallel the transported picture is provided to video hardware **16** (as shown in FIG. **1** already) for converting the transported picture into video signal for presentation as an image **27**, e.g. on a screen of a computer or a patient monitor.

[0084] In the fourth device **120** the secure pattern **122** is extracted and decoded to obtain the value of the counter **124** (that corresponds to the counter **91** used by the third device **80**). The pattern **122** can be regarded an “image for algorithms”. A very well-known example of such an “image” would be a QR code. It is information encoded as an image, which can easily be discovered by an algorithm in the overall image. The pattern may be hidden in the image (e.g. by steganography), and needs to be extracted from the common picture **121**. The pattern **122** thus contains the information entered by the pattern generator **86**, i.e. at least the counter value (of the original counter **91**) or information generated from it, which changes (i.e. the extracted counter value **124**).

[0085] The picture **121** may also represent a collection of many sources (i.e. many devices **80**). In such an embodiment the fourth device **120** will also find many patterns **122** and extract many counters **124**. The collection unit **126** can collect these values and create a list **127**. This list must change over time: No counter may remain too long in the list **127**. A check unit **129** checks this, e.g. by comparing the current list with at least one older list. A watchdog **131** may be used to monitor that these checks take place at all.

[0086] The counter **130** is optional. If it is identical to the counter **91**, concrete representations can be checked not only for “changes”, but even the age can be determined. In other words, entering a pattern into the image is a declaration of a watchdog, and the device checks it by expanding or distributing a single watchdog **131** for many sources **80**.

[0087] By decoding the pattern other data may be extracted as well. For instance, this path is a way to decompose the content of the display and to extract debug and test information **125** (independent of the check) from the image, for example also the original data **84**, without requiring a special image recognition (e.g. using OCR). These debug and test data **125** is not relevant for the update check, but is a useful side result.

[0088] According to this embodiment an effective, fast and safe operation of displaying of image data, which comprise information being relevant to safety, which may change over the time and/or displaying of which has to be up to date (i.e., if changes of at least one part of the image have occurred, these changes have to be visualized, displayed immediately), can be ensured. A secured image is generated by adding (invisible) information to a source image, i.e. information, which is not displayed and/or which is not visible or is almost invisible when displaying the corresponding image. This information may be seen as security pattern(s). Further, instead of the source image, the secured image is displayed, wherein the currentness of the displayed secured image is checked by use of the added (invisible) information like the security pattern(s). The added (invisible) information like the security pattern(s) is updated from time to time. Thus, if the operation of displaying the secured image is executed correctly, the displayed secured image has to comprise the current added (invisible) information like the current security pattern(s), i.e. the current added (invisible) information or current security pattern(s) last amended.

[0089] Further, it is checked independently of a watchdog whether the screen freeze detection runs at all. With this, it is checked in the whole chain if the respective processing elements are running and if the transport processes are running. Optionally, other (alternative or additional) mechanisms may be used on the way of the data, which may include watchdogs that can e.g. ensure the execution of an algorithm. For instance, if a watchdog is silenced when the flag “Data is Valid” is set, the chain of data up to this point is checked as well. This may be useful when the data are passed to external services that only wish to obtain unmodified data (i.e. data without entanglement). FIG. **7** shows a corresponding embodiment of a device **50** (as shown in FIG. **4**),

with an additional watchdog **140** and a transmission medium **150** for exporting the untangled data. [0090] FIG. **8** shows a schematic diagram of a system **300** executing or supporting the monitoring of displaying image data according to an embodiment of the present invention, which may be used as an implementation of the third and fourth devices **80**, **120**. The system is particularly configured to generate and display a stream of images comprising areas showing alarms or critical vital signs of a patient, wherein the images may change over time. The system **300** comprises a secured image generator **311** and an observer **321**, which may be comprised in two separate devices or in one device.

[0091] Usually, an image source renders image information and then writes it into a storage like a frame buffer, for example, for displaying the image information. This usual case is shown by components or entities **333** and **334**, where the component **333** is a conventional image source and the component **334** is storage like a frame buffer, for example, and where the image source **333** writes image information or data, rendered or generated by the image source **333**, into the frame buffer **334**.

[0092] According to the present embodiment, the secured image generator **311** is a secured image source and is configured to execute a reliable process that renders critical data, which comprise information being relevant to safety, which may change over the time and/or displaying of which has to be up to date (i.e., if changes of at least one part of the image have occurred, these changes have to be visualized, displayed immediately), into a critical source image **332**. However, before writing the source image **332** into the frame buffer **334**, according to the present embodiment, the secured image generator **311** executes the reliable process by generating or rendering at least one secure pattern **331** that is combined or overlaid with the source image **332** thereby yielding or generating a secured image **313**. This secured image **313** is then written into the frame buffer **334**.

[0093] According to the present embodiment, the frame buffer **334** may store also other images, which are generated by other image sources **333**, besides the secured images **313**, which are generated by the secured image generator **311**. In such a case, such other images may be stored or positioned in the storage or frame buffer **334** such that they do not overlay or otherwise disturb the secured images **313**.

[0094] According to the present embodiment and also according to further embodiments of the present invention, in order to not disturb the user when the user views the displayed secured image **313**, the secure pattern(s) may be kept unperceivable or invisible. To this, known techniques like steganography or watermarking may be used with regard to the secure pattern(s).

[0095] If the storage or frame buffer **334** is the final storage or frame buffer before displaying, i.e., if the images displayed by a displaying device is taken from the storage or frame buffer **334**, according to the present embodiment, the (displaying operation) observer **321** is configured to take the secured image **313** from the storage or frame buffer **334** for performing the monitoring of displaying the secured image **313** by the displaying device. This case is visualized by arrows **336** in FIG. **8**.

[0096] However, if at least one further storage or frame buffer **335** is used for storing the secured image **313**, i.e., if the images displayed by the displaying device is taken from a further storage or frame buffer **335** as a final storage or frame buffer, according to the present embodiment, the observer **321** is configured to take the secured image **313** from the further storage or frame buffer **335** as the final storage or frame buffer for performing the monitoring of displaying the secured image **313** by the displaying device. This case is visualized by arrows **337** in FIG. **8**.

[0097] In general, if the displaying device is configured to take a secured image **313** from a storage or frame buffer **334**, **335** for displaying the secured image **313**, the observer **321** can read out the secured image **313** out of the final frame buffer **334**, **335** and can extract the added (invisible) information **331** like the security pattern(s) and, subsequently, update the (invisible) information or security patterns **331** and/or decide, which image parts of the secured image **313** are displayed correctly, i.e., whether the current secured image **313** or the current secured image parts

respectively are displayed by the displaying device.

[0098] Hence, according to this embodiment the system **300** substantially comprises: [0099] a secured image generator **311** configured to generate a stream of secured images based on a stream of source images comprising areas showing alarms or critical vital signs of a patient, by generating at least one secured image part in the source images, wherein the secured image part is generated by combining a part of the source image with a security pattern generated by the secured image generator, wherein said security pattern is updated with time; [0100] a memory storage **334** to store the secured images; and [0101] an observer storage **321** configured to detect the security pattern from the secured image and to check the currentness of the detected security pattern by comparing the detected security pattern with an expected current security pattern.

[0102] Further, an image transmitter (not shown) coupled to the memory storage **334** and a patient monitor (not shown; preferably including the observer storage **321**) configured to receive from the image transmitter a secured image from the memory storage and display it may be provided. The observer storage **321** may be configured to tap said secured image during its transmission from the memory storage to the patient monitor.

[0103] In certain applications the history of measured values (e.g. sensor data) may be stored to use them later at different time or for different purposes. It is often sufficient to be able to do this since current values are just further ahead in the data and algorithms do not need anything else at all. In other words, no messages are stored, but only an information where the values stand. This is a normal case since, for example, this is always done when data are obtained from different sources, which have to be delayed differently, e.g. with a ring buffer.

[0104] It can happen that this memory is accessed in a staggered manner. If there are directly measured values, this is not noticed, at least not immediately. An access to an array with an index is on machine level an addition of an address of the array and the index. Now, if the value “address of the array” is (slightly) broken, the array is still accessed when reading it out. So the values are plausible, but still wrong (if not protected by the present invention).

But the index is identical or at least related to the counter. So if the values in the array are entangled (e.g. interleaved) with the counter, this kind of offset can be recognized, and it can be checked whether the correct data are used. Considering that the memory comprises many arrays, which can be very large, and considering that the measured values are often very similar, it is possible to compute probabilities for problems, which can be improved by the present invention. Hereby, it is important to know that the index is typically calculated, but the address was rather stored by the array, and thus potentially easier to destroy than the index value. But if is wrong, old data may be accessed which would potentially not be noticed.

[0105] The entangling provided according to the present invention provides as an additional advantage that a check of the currentness of data is definitely enforced. Should there be reasons not to entangle the input data (or not all input data), e.g. due to transport of the input data using a protocol that does not allow such an entangling, the hash may nevertheless be generated and transported, although fewer options for checking the transported input data are available then.

[0106] The present invention may be utilized in several areas, where displaying of image data is done, for example, in the area of medical technology, where data of patients comprising measured values and/or captured image data are displayed for monitoring conditions of the patients and where the data is displayed as images and may change over the time. The present invention is, however, not restricted to a specific area of use.

[0107] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

[0108] 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. A single element or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

[0109] A computer program may be stored/distributed on a suitable non-transitory medium, such as an optical storage medium or a solid-state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the Internet or other wired or wireless telecommunication systems.

[0110] Any reference signs in the claims should not be construed as limiting the scope.

## Claims

1. A device for enabling detection of currentness of data, the device being configured to: obtain input data; generate entangled data by entangling the obtained input data with a continuously changing counter, wherein the entangled data requires untangling by use of the same counter to reveal the original input data; generate a hash by applying a hash function on the obtained input data; combine the entangled data and the hash into output data; and output the output data for transport over a transport medium.
2. The device as claimed in claim 1, wherein the device is configured to generate the entangled data by entangling the obtained input data with the current time or a periodically changing value as continuously changing counter.
3. The device as claimed in claim 1, wherein the device is configured to generate the entangled data by entangling the obtained input data by applying an exclusive OR operation on bits or values of the obtained input data and the continuously changing counter or by scrambling the obtained input data and the continuously changing counter.
4. The device as claimed in claim 1, wherein the device is configured to generate the hash by applying a hash function on the obtained input data and the continuously changing counter.
5. The device as claimed in claim 1, wherein the device is configured to output the hash with a lower data rate than the entangled data.
6. A device for detection of currentness of data, the device being configured to: obtain input data transported over a transport medium, the input data including entangled data and a hash; derive the entangled data and the hash from the obtained input data; generate untangled data by untangling the entangled data using a counter that has been used for entangling, wherein the entangled data requires untangling by use of the same counter to reveal the original input data; generate a check hash by applying a hash function on the untangled data; compare the generated check hash with the derived hash; and determine currentness and validity of the generated untangled data based on the comparison of the generated check hash with the derived hash.
7. The device as claimed in claim 6, wherein the device is configured to determine that the generated untangled data are current and valid if the generated check hash is identical to the derived hash.
8. A system comprising: a first device for enabling detection of currentness of data, wherein the first device is the device as claimed in claim 1; and a second device for detection of currentness of data, wherein the second device is configured to: obtain input data transported over a transport medium, the input data including entangled data and a hash; derive the entangled data and the hash from the obtained input data; generate untangled data by untangling the entangled data using a counter that has been used for entangling, wherein the entangled data requires untangling by use of the same counter to reveal the original input data; generate a check hash by applying a hash function on the untangled data; compare the generated check hash with the derived hash; and determine currentness and validity of the generated untangled data based on the comparison of the

generated check hash with the derived hash.

**9.** The system as claimed in claim 8, further comprising: a third device configured to generate a source image from the data and to generate a secured image based on the source image by generating at least one secured image part, wherein the secured image part is generated by combining a source image part of the source image with a corresponding secure pattern; and a fourth device configured to display the secured image, to detect the security pattern from the secured image and to check the currentness of the detected security pattern.

**10.** The system as claimed in claim 8, wherein the system is a patient monitoring system and wherein at least the fourth device is included or represents a patient monitor.

**11.** The system as claimed in claim 10, wherein the first device includes or represents a data processor, the second and third devices include or represent an image generator.

**12.** The system as claimed in claim 9, wherein the system is configured to generate and display a stream of images comprising areas showing alarms or critical vital signs of a patient, wherein the images may change over time, and wherein the system comprises: a secured image generator configured to generate a stream of secured images based on a stream of source images comprising areas showing alarms or critical vital signs of a patient, by generating at least one secured image part in the source images, wherein the secured image part is generated by combining a part of the source image with a security pattern generated by the secured image generator, wherein said security pattern is updated with time; a memory storage to store the secured images; and an observer storage configured to detect the security pattern from the secured image and to check the currentness of the detected security pattern by comparing the detected security pattern with an expected current security pattern.

**13.** A method for enabling detection of currentness of data, the method comprising: obtaining input data; generating entangled data by entangling the obtained input data with a continuously changing counter, wherein the entangled data requires untangling by use of the same counter to reveal the original input data; generating a hash by applying a hash function on the obtained input data; combining the entangled data and the hash into output data; and outputting the output data for transport over a transport medium.

**14.** (canceled)

**15.** A non-transitory computer readable medium that stores therein a computer program comprising program code means for causing a computer to carry out the steps of the method as claimed in claim 13 when said computer program is carried out on the computer.

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