

METHOD AND APPARATUS FOR MONITORING A STRUCTURE

Field of the Invention

The present invention relates to a method and apparatus
5 for monitoring a structure and, in particular, but not
exclusively, to monitoring a barrier to determine an
intrusion across the barrier. The barrier may be a fence
or other partition, or a region of the ground. In other
embodiments, the structure may be other than a barrier or
10 region of the ground which is to be monitored for
intrusion and may comprise a mechanical device or the
like, a communication network, or other machine.

Background of the Invention

15 One of the challenges of all sensing systems is to be able
to operate in a number of hostile environments. Intrusion
detection systems, which are often installed in outdoor
environments and need to operate during periods of heavy
wind or rain, or close to nearby traffic crossings, are no
20 exception.

In any sensing system, a nuisance alarm can be defined as
an alarm caused by an event that is not of interest for
that sensing system. For intrusion detection systems, this
25 relates to non-intrusion events such as wind, rain,
vehicular traffic and other environmentally related non-
intrusion events. Nuisance alarms can adversely affect the
performance of intrusion detection systems, as well as the
confidence of the system operator. The minimization of the
30 nuisance alarm rate of intrusion detection systems, and
indeed of any sensing system, is therefore critical for
its successful performance and confidence of operation.

An important part of nuisance alarm handling involves
35 being able to recognize the nuisance event being detected
by the sensing system, as well as being able to
discriminate between nuisance events and intrusion events.

A number of different signal processing techniques can be used to achieve this and can range from simple filtering techniques, to adaptive filtering techniques, to a number of time-frequency analyses. The crux of all event
5 recognition and discrimination techniques is the signal classification process, which involves extracting and identifying unique features in event signals. The event signals may represent isolated individual events (for example intrusion, rain, wind or traffic), or a number of
10 events occurring simultaneously (for example, an intrusion event during heavy rain). In this latter case of simultaneously occurring events, an effective technique for extracting the event of interest from the event of non-interest is required.

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In some instances it is also desirable to be able to classify the particular type of nuisance event.

The intrusion detection system may be of the type
20 described in US patents 6621947 and 6778717, and US patent application 11/311,009. It is based on a bidirectional Mach Zehnder (MZ) which can be used as a distributed sensor to detect and locate a perturbation anywhere along its sensing arms. It will be referred to as a locator sensor.

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US5510765 discloses a security system which is based primarily around a glass breakage sensor to detect an intrusion into the vehicle that does not involve the opening of doors but rather an intrusion via window/glass
30 breakage whilst the doors are closed. The processor reads and sums data counts in regular pulses and divides the resulting sum to arrive at an auto calibration count of noise levels. The calibrated noise levels are compared

with upper and lower limits that are noise levels which trigger further analysis when exceeded by the data counts.

Summary of the Invention

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The object of a first aspect of the invention is to provide method and apparatus for distinguishing between an event of interest and a nuisance event.

10 According to a first aspect of the present invention, there is provided an apparatus for monitoring a structure against intrusion as set out in Claim 1.

According to a second aspect of the present invention,
15 there is provided a method monitoring a structure against intrusion as set out in Claim 5.

Brief Description of the Drawings

20 A preferred embodiment of the invention will be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a block diagram of an apparatus for locating an event of an intrusion;

25 Figure 2 is a graph showing parameters used in a level crossing rate technique used in the invention;

Figure 3 is a graph showing level crossings per defined blocks in a noise induced environment;

Figure 4 is graphs showing time domain representation
30 of a heavy rain nuisance event and level crossings per block;

Figure 5 is a graph showing the result of dynamically determined event thresholds;

Figure 6 is a graph showing detecting of an intrusion event during heavy rain periods;

Figure 7 is diagram of actual screen displays showing detection identification of an intrusion event;

5 Figure 8 is a flow chart illustrating the operation of the system according to the preferred embodiment for discriminating between nuisance events and required events such as an intrusion;

10 Figures 9 and 10 are diagrams showing actual display screens giving an example of the identification of an event during artificially stimulated background noise events to show the dynamic event threshold;

Figure 11 is a block diagram showing a second embodiment of the invention;

Figure 12 is a display showing the effect of an intrusion event caused by cutting a fence on a signal detected by one embodiment of the invention used to classify the intrusion event;

5 Figure 13 is a representation of various features extracted from the display of Figure 12;

Figure 14 is a display showing an intrusion event caused by climbing a fence;

10 Figure 15 is a graph showing extracted features from the display of Figure 14;

Figure 16 is a graph showing a frequency spectrum of a detected event;

15 Figure 17 is a graph showing the difference between a intrusion event caused by cutting and an intrusion event caused by climbing over a fence; and

Figures 18, 19, 20, 21, 22 and 23 are graphs showing the classification and recognition of various events.

20 Detailed Description of the Preferred Embodiment

Referring to Figure 1, the locator sensor locates perturbations on its sensing arms by using the difference in time of arrival of the counterpropagating signals at Det1 and Det2. Additionally, using the event signals
25 detected by both detectors (Det1 and Det2), it is possible to apply the appropriate signal processing techniques to classify the signals and perform both signal identification and signal discrimination.

30 By measuring and analysing the level crossing rates (LCR) of a number of different intrusion and nuisance event signals obtained from a number of installed locator systems in the field, the LCR can form the basis of both event signal recognition and discrimination techniques for
35 reducing nuisance alarm rates. In particular, using the LCR technique with fence-mounted locator systems of the type described in the above US patents and application,

zero nuisance alarm rates due to heavy rain have been achieved, as well as the accurate detection and location of intrusion events, such as climbing, during periods of heavy rain.

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LCR (Level Crossing Rate) is defined as the number of times per unit duration that the envelope of a signal in the time domain crosses a given value in the positive direction.

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The LCR technique is defined by the number of crossings (in the positive direction) of an input vector through a given threshold. The implemented LCR can be given by

$$\text{LCR} = \sum_{n=0}^{N-1} \Psi\{(x(n) \geq a) \& (x(n-1) < a)\}$$

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where x is a signal of length N , the parameter a is the level threshold, and the indicator function $\Psi\{K\}$ is 1 if its argument K is true, or 0 otherwise.

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This can be applied to the event signals received by the fibre optic locator system described in Figure 1, to extract the following LCR signal features: 1) the minimum LCR over a specified time period; 2) the maximum LCR over a specified time period; 3) the mean LCR over a specified time period; 4) the standard LCR deviation over a specified time period; and 5) the total LCR.

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Any combination of these features can be used to determine fixed thresholds for defining particular nuisance events, whilst an adaptive threshold can be used to detect an intrusion event during a simultaneous nuisance event.

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The use of the LCR technique described previously to detect and recognize nuisance signals caused by heavy rain on fence-mounted fibre optic intrusion detection systems,

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as well as the detection of climbing events during continuous periods of heavy rain is now described.

With reference to Figure 1, the basic system as disclosed
5 in the above-identified US patents and applications will be briefly described.

Light from a laser source 10 is launched into a coupler C1 which in turn launches the light into polarisation
10 controllers for both the clockwise and counter clockwise directions 12 and 14 respectively. The light is then launched through couplers C2 and C3 into a lead in optical fibre 16 and a lead in optical fibre 18. The fibre 16 is connected to a coupler C4 so that the light from the lead-
15 in fibre 16 propagates through sensing fibres 20 and 22 in the clockwise direction and then through a coupler C5 to the lead in fibre 18 and back through coupler C3 to detector Det2. Light from the fibre 18 is received by coupler C5 and launched in the counter clockwise direction
20 into the sensing fibres 20 and 22 and propagates through the coupler C4 to the lead-in fibre 16 and through coupler C2 to the detector Det1.

The detectors Det1 and Det2 are connected to a processor
25 50 schematically shown in controller unit 5 of Figure 1 so that, in accordance with the above US patents and US patent application, the signals are processed to determine when an event occurs and the location of that event.

30 According to the preferred embodiments of the present invention, the processor 50 also discriminates between events such as various different classes of required events such as cutting or climbing a fence , as well as different nuisance events caused by rain, wind and other
35 environmental activity, as well as other nuisance events such as the throwing of stones against a fence or other human caused nuisance events.

The processor 50 discriminates between the nuisance events and an actual intrusion event so that only intrusion events are made the subject of an alarm to identify an intrusion or other event which is of interest, as well as providing information as to the specific nature of the nuisance events which are being caused.

The manner in which nuisance events are discriminated from actual required events will be described with reference to Figure 2 to 8.

With reference to Figure 2, a time domain signal is shown which is received from the fibre optic sensor (such as fibre 18 via detector Det2) that is being acquired at a sampling rate of approximately 40 kHz. The signals are divided up into block durations, or "Blocks" of a fixed duration (say 10ms).

For each block the number of signal "Level Crossings" is counted. A "Level Crossing" is said to have taken place when the acquired signal goes from below a specified "Noise Level Threshold" to above that threshold. The "Noise Level Threshold" is set to be just above the background system noise and, for example, can be set to 0.085 volts by the processor 50 if the system noise is 0.083 volts.

The number of "Level Crossings" for each "Block" is then monitored to allow the signal to be classified according to predetermined criteria. An "Event", that is, an intrusion event, is said to have occurred when the number of Level Crossings within a block goes above a specified "Event Threshold" (see Figure 5).

The number of "Level Crossings" per block is monitored for a period of time known as the "Noise Detect Duration"

(Figure 3). Using the fibre optic based intrusion detection system described in Figure 1, analysis of nuisance signals caused by heavy rain periods have shown that a relatively constant range of level crossings per block is maintained during the rainy periods. This range is defined as the "Noise amplitude variation". If over the "Noise Detect Duration" period the number of level crossings does not vary by more than the "Noise amplitude variation", then the signal over this period of time is assumed to be caused by heavy rain, and therefore alarms during this period can be ignored. A similar approach can be applied to other nuisance events such as wind or nearby traffic events caused by vehicular or train crossings.

Figure 3 shows a typical plot of the level crossings per block for a signal caused by heavy rain on a fence mounted fibre optic intrusion detection sensor. The Noise Detect Duration is equivalent to 20 blocks (if a block had a duration of 10 ms then the noise detect duration would be 200 ms). In this case the Noise amplitude variation has been set to 10. It can be seen that the number of "Level Crossings" per "Block" have not varied by more than the "Noise amplitude variation" over the "Noise Detect Duration" period. The signal related to these level crossings is therefore considered as Background Environmental Noise, and any alarms it produces are handled accordingly and not treated as an event alarm.

An example of a heavy rain nuisance signal as obtained from a fence mounted fibre optic locator system is shown in Figure 4. A plot of the level crossings per block (LCR) versus block number is also shown. The heavy rain nuisance signal, which is continuous, shows a consistent LCR count with a relatively small variation. These features can be used to detect and identify heavy rain induced nuisance alarms.

A required event (or intrusion event) is said to have occurred when the number of "Level Crossings" in a given block goes above an "Event Threshold". The "Event Threshold" is dynamic as it changes depending on the amount of Background Environmental Noise currently in the system, which can change as the intensity of the rain varies.

Whenever a new block is received, the method and apparatus determine whether or not the signal is just background noise. If the signal is just background noise then the current "Event Threshold" is updated. The new "Event Threshold" will equal the maximum "Level Crossing" count over the last "Noise Detect Duration" plus the "Event Threshold Margin".

Figure 5 shows how the "Event Threshold" which is updated after the 30th block has been processed. In the example above the maximum number of level crossings over the last "Noise Detect Duration" is 18. The "Event Threshold Margin" is set in the processor 50 to be 10. As the variation of level crossings over the last "Noise Detect Duration" has not varied by more than the "Noise amplitude variation" the "Event Threshold" is updated to 18 plus 10. In this example the new "Event Threshold" is set to 28. This allows the Event threshold, that is, the threshold above which an event will be recognized as an intrusion event, to dynamically change with any variation in the maximum level crossings which may occur as the intensity of the rain varies.

Figure 6 shows an example of an event being detected in the 31st block of data received. The intrusion event essentially increases the number of level crossings in the detected time domain signal above the background level crossings caused by the heavy rain allowing for the intrusion event to be detected and recognized. In the

case of the fibre optic based locator system shown in Figure 1, it also allows for the correct part of the signal to be processed for an accurate event location to be determined. The LCR technique therefore can also be
5 used as an effective method for the discrimination between intrusion events and nuisance events.

An example of detecting and identifying an intrusion event during a heavy rain period using the locator intrusion
10 detection system on a 1.6 km fence perimeter is shown in Figure 7.

The example in Figure 7 shows the detection of an intrusion event during a manually stimulated background
15 nuisance event on a 1.6km long sensing system according to the above embodiment. The dynamic Event Threshold adjusts itself to cater for any variation in the level crossings of the nuisance signal.

20 The LCR technique described above can also be applied to other nuisance events such as wind, vehicle traffic and train traffic.

25 Figure 8 is a flow chart showing the detection of an event and the adjustment of the various threshold levels to resulting nuisance events such as rain etc from generating required event alarms. As shown in Figure 8 the level crossings in a block is counted and if the number of level
30 crossings is greater than the event threshold an alarm is generated indicative of an actual required event to alert the system operator that an intrusion or other event has occurred. The process then goes to the next step in which the variation of the level crossing count per block is
35 compared to the noise amplitude variation. If the answer is no the system goes back to the start and the level crossings are again counted. If the answer is yes the

system goes to the next step in which the event threshold is updated. A pure nuisance data record is also updated for use in the embodiment of Figure 11. The system then goes back to the start where the number of level crossings are again counted in each block.

With reference to Figures 9 and 10 diagrams illustrating actual screen displays are shown in which in Figure 9 the upper part of the display shows a combined nuisance-intrusion event time domain signal whilst the lower part of the display shows the level crossings per block versus block number. Figure 10 shows the dynamic event threshold which adjusts itself to cater for any variations in the level crossings caused by the nuisance signals. As can be seen in Figure 10 the dynamic event threshold raises and lowers with the background nuisance event so that the system and method according to preferred embodiments is continually self-adjusting when a rain event occurs to raise the dynamic event threshold so that the rain does not cause the generation of event alarms indicative of an intrusion, and again lowers itself when the rain reduces. Thus, the preferred embodiment effectively provides a system in which the mode of operation changes depending on the environmental nuisance noise to which the system is subject at any particular time. When rain occurs the system effectively switches to a mode in which the event threshold is raised so that the rain does not cause event alarms and when the rain ceases the system goes back to its normal state with the event threshold lowering.

Figure 11 shows a second embodiment of the invention using a Frequency Domain Denoising (FDD) method.

In some situations, the contribution of the nuisance signal to the combined nuisance-event signal can affect the accuracy of the location calculation in the locator sensing system. This is especially the case when the

background nuisance or noise signal forms a significant part of the overall signal.

5 The Frequency Domain Denoising (FDD) method reduces the amount of background nuisance or noise level in the combined nuisance and intrusion event signal and improves the event signal's signal-to-noise ratio (SNR). This method is used in conjunction with the LCR technique described earlier to characterize both the nuisance or
10 noise background signal, and to identify when the event signal of interest occurs.

As an example, the FDD approach for extracting an event signal from a strong background nuisance heavy rain signal
15 is summarised as follows:

1. Monitor the time domain signal and its LCR during heavy rain.
2. If the LCR exceeds the Event Threshold it means that an intrusion event (such as a climb event) has
20 occurred during heavy rain. Identify the block(s) of data which corresponds to the intrusion event
3. Locate a block of data before the event that characterizes the pure rain event and convert it into the frequency domain using a Fast Fourier
25 Transform (FFT).
4. Select some of the dominant frequencies from the FFT representation of the rain block. A threshold based on a percentage of the maximum peak in the FFT graph is used to select these frequencies.
- 30 5. After selecting the dominant frequencies of the rain signal, remove these frequencies from the block(s) which contains the combined intrusion and rain signal.

35 With reference to Figure 11 as mentioned above, the time domain signal shown in Figure 2 is monitored and the level crossing rate is used to determine whether a nuisance

event such as rain is occurring. If the level crossing rate exceeds the event threshold, in the manner described above, an intrusion event is also occurring. As shown in Figure 11 signal S from one of the detectors Det1 or Det2 indicative of the nuisance event (i.e. rain) and/or the required intrusion event (such as a fence climb event) is also occurring. A signal indicative of the pure nuisance signal such as that caused by the rain event without an actual intrusion is supplied to a fast Fourier transform algorithm 61 and a fast Fourier transform is performed on the signal to determine selected frequencies within the pure nuisance signal. A signal S' within the block or blocks in which a combined nuisance-intrusion event has occurred is also supplied to a fast Fourier transform algorithm 60 and a fast Fourier transform is performed on that signal. Thus, the signals supplied to the algorithms 60 and 61 are converted to the frequency domain using the fast Fourier transform. The processor 50 removes all or a significant proportion of the selected frequencies from the pure nuisance frequency domain signal produced by the algorithm 61 from the frequency domain signal produced by the algorithm 60. This signal is therefore supplied to the cross correlation circuit 64 and is indicative of the pure event signal which is of interest. In Figure 11 channel 1 represents the clockwise MZ output signal propagating in the fibre 18 and channel 2 represents the counterclockwise MZ output signal propagating in the fibre 16. The channel 2 signal is processed in exactly the same way as the channel 1 signal so that its actual intrusion signal is supplied to the cross correlation circuit 64 so that the fact that an event has occurred can be determined and its location also determined.

This technique essentially removes a significant amount of the background nuisance or noise contribution from the combined nuisance-intrusion signal which in effect extracts the intrusion component from the total signal.

Figures 12 to 23 relate to an embodiment of the invention in which an actual required intrusion event is classified so the event can be determined as a particular type of event such as an intrusion caused by climbing over a fence, or some other event such as throwing stones at the fence.

Different types of intrusions can be identified since they can generate unique vibration signals with different signatures. Figure 12 is a display showing the effect of cutting a fence on the signal detected by one of the detectors Det1 or Det2 in Figure 1. As shown in Figure 12 the signal has a very sharp rise and then decays over time.

Figure 13 is a graph showing the number of level crossings for each block duration. As is shown in Figure 13 when the cutting event starts there is a large number of level crossings for example, at block 10 and the number decreases until block 20 where the number is zero.

Four features are extracted from Figure 13 being;

- the total number of level crossings over a specified time period;
- the duration of the level crossings;
- the angle of the falling edge of the level crossings; and
- the angle of the rising edge of the level crossings, θ as shown in Figure 13.

In Figures 12 and 13 the total number of level crossings measures the area under the level crossings versus block number graph over a specified period of time. In the example shown in Figures 12 and 13, the length of the proposed data was set to 2480 samples, sampled at 40Khz. The duration of the level crossings is the number of

consecutive blocks that have values greater than zero.
The slope of the level crossings is the slope of the
falling edge of the graph shown in Figure 13 which shows
the points x_1, y_1 and x_2, y_2 from which the slope is
5 determined.

The slope is therefore given by $(y_2 - y_1)$ divided by $(x_2 - x_1)$.

Figures 14 and 15 are similar to Figures 12 and 13 except
10 that they show a climbing event. In Figure 15 a threshold
has been used to select one of the slope points for the
falling edge which is the first peak in Figure 15 above
the threshold and the maximum point in Figure 15 is used
to determine the angle of the rising edge θ .

15 As is apparent from Figures 13 and 15 the rising edge in a
cutting event forms approximately a right angle with the
x-axis, whilst the rising edge for a climbing event forms
an acute angle less than 90° . This feature is very
20 important for climbing and cutting classification.

In one embodiment shown in Figure 16 a time-frequency
based classification system is used in which a fast
Fourier transform is performed over the intrusion event
25 time interval. The fast Fourier transform is performed
only over the detected intrusion intervals and not over
the entire domain signal. The features extracted with
this method are summarized as follows:

- 30 detection of the intrusion event interval;
- the fast Fourier transform spectrum is calculated
for the detected event;
- for the frequency spectrum of the intrusion
event, a threshold is selected. In the example
of Figure 16, the threshold is 50% of the peak
35 magnitude of the spectrum;
- the minimum frequency and maximum frequencies
above that threshold are selected and the centre

frequency is calculated by $(f_{\min}) + (f_{\max})$ divided by 2; and
the centre frequency calculation is repeated for successive detected events over time.

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Figure 17 shows a comparison of the centre frequencies of 10 fence cut and fence climb events. The fence cutting events have a more consistent centre frequency when compared to the climbing events. This feature can be used in conjunction with the previous features to confirm the presence of cutting events.

After extraction of the feature vectors from the signal, decision is then taken about the class the signal belongs to (whether cutting or climbing event). This process is performed with an appropriate classifier such as a neural network. For every point in a feature space, a corresponding class is defined by mapping the feature space to the decision space. The borders between the classes are formed by training the neural network. This is done with a suitable set of cut and climb event data. Once borders are fixed with a set of training data, the performance of the classifier is tested with a set of test events (cut and climb) that is independent of the training set.

The extracted level crossing base features described previously for the cutting and climbing events can be used as inputs to the neural network. The neural network is efficient regardless of data quantities. Neural networks can learn from examples and once trained, are extremely fast algorithms making them suitable for real time application. Event classification by a neural network does not require any statistical assumptions regarding the data. The network learns to recognize the characteristic features of the data to classify the data efficiently and accurately.

In another embodiment of the invention a linear classifier can be used to classify events such as a stone-throwing event, fence cutting event or fence climbing event. The
5 purpose of this classifier is to set boundaries between various classes and this type of classifier is suitable for classes, that is particular events, that have little or no overlap between them for a set of given features.

10 Figures 18 to 20 show the classification and recognition of cutting and climbing events using different combinations of features. The two dimensional features for these figures respectively are:

event duration versus slope of the event;
15 total level crossings versus slope of the events;
and
total level crossings versus duration of the events.

20 As can be seen from Figure 18 cutting events are below the line in Figure 18 and climbing events above the line. Thus, an event which falls above the line in Figure 18 can be classified as a climbing event and that which falls below the line as a cutting event.

25 Similar comments apply to Figures 19, 20, 21 and 22.

In Figure 18 classification and recognition is performed using slope and duration of the events, in Figure 19 slope
30 and total level crossings of the events is used, in Figure 20 duration and total level crossings of the events is used.

Figure 21 shows the use of horizontal and vertical
35 threshold lines to separate cutting events and climbing events.

Figure 22 shows the classification and recognition of cutting and climbing events using the angle of the rising edge of the level crossings versus the slope of the falling edge of the level crossings.

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Figure 23 shows classification and recognition of three events being the cutting and climbing events previously described and a stone throwing event. The results show that the stone throwing events have comparable slope with
10 the cutting events but different in their total level crossing rate. Also, Figure 23 shows that some of the stone events share similar total level crossings with climb events but differ in their slopes.

15 It will be understood to persons skilled in the art of the invention that many modifications may be made without departing from the scope of the invention.

In the claims which follow and in the preceding
20 description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense,
i.e. to specify the presence of the stated features but
25 not to preclude the presence or addition of further features in various embodiments of the invention.

CLAIMS

1. An apparatus for monitoring a structure against intrusion comprising:

5 a sensing device for producing a detected signal for determining a change in or to the structure; and

a processor for processing the detected signal so as to distinguish between noise in the signal indicative of a nuisance event and an intrusion event; characterised in

10 that

the processor is conditioned to analyse the detected signal over successive noise detection time intervals each having a plurality of successive time block durations to derive for each block duration a count of the number of
15 level crossings, being the number of times samples of the signal cross a noise level threshold in a direction to exceed that threshold during the block duration, to set a noise amplitude variation range being a permitted range of variation in the number of level crossings per time block
20 duration, and if the counts of level crossings in all time block durations during a noise detection time interval fall within the variation range, regard the signal as indicative of a nuisance event and not an intrusion event, to set an event threshold level being a number of level
25 crossings per time block duration in excess of the maximum number of level crossings within the noise amplitude variation range, and to indicate that an intrusion event has occurred if the number of level crossings in one or more block duration periods is above the event threshold,
30 wherein the processor is further conditioned to set the event threshold as a dynamic threshold that changes in response to changes in the number of level crossings due to nuisance events when the variation of counts of the number of level crossings in each block duration over the
35 last noise detection time interval has not varied more

than the noise amplitude variation range and the event threshold is not updated when the variation of counts of the number of level crossings in each block duration over the last noise detection time interval has varied more
5 than the noise amplitude variation range.

2. The apparatus of claim 1, wherein the processor is conditioned to set the event threshold as the maximum count of level crossings per time block duration occurring
10 during a preceding noise detection time interval plus an event threshold margin.

3. The apparatus of claim 2, wherein the event threshold margin is a predetermined margin.
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4. The apparatus of any one of claims 1 to 3, wherein the processor is conditioned to generate an alarm signal on detection of an intrusion event.

20 5. A method monitoring a structure against intrusion comprising:

monitoring a change in the structure by a sensing device to provide a detected signal; and

processing the detected signal so as to distinguish
25 between a nuisance event and an intrusion event;

characterized by the steps of analyzing the detected signal over successive noise detection time intervals each having a plurality of successive time block durations to derive for each block duration a count of the number of
30 level crossings, being the number of times the signal crosses a noise level threshold in a direction to exceed that threshold during the block duration, setting a noise amplitude variation range being a permitted range of variation in the number of level crossings per time block
35 duration and if the number of level crossings in each of

the time block durations during a noise detection time interval falls within the variation range, regarding the signal over the time interval as indicative of a nuisance event and not an intrusion event, setting an event
5 threshold level which is a number of level crossings per time block duration in excess of the maximum number of level crossings per time block duration within the noise amplitude variation range, and indicating that an intrusion event has occurred if the number of level
10 crossings in one or more block duration periods is above the event threshold level, wherein the event threshold is set as a dynamic threshold that changes in response to changes in the number of level crossings due to detected nuisance events when the variation of counts of the number
15 of level crossings in each block duration over the last noise detection time interval has not varied more than the noise amplitude variation range and the event threshold is not updated when the variation of counts of the number of level crossings in each block duration over the last noise
20 detection time interval has varied more than the noise amplitude variation range.

6. The method of claim 5, wherein the event threshold is set as the maximum count of level crossings per time block
25 duration occurring during a preceding noise detection time interval plus an event threshold margin.

7. The method of claim 6, wherein the event threshold margin is a predetermined margin.

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8. The method of any of claims 5 to 7, comprising generating an alarm when the event threshold is exceeded.