Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
This invention relates to intruder detection systems. There is a growing demand for low cost systems able to reliably detect intruders both within and around the perimeter of sensitive facilities and locations. Many approaches have been developed which are able to detect intruders, but they are costly to manufacture or suffer from reliability problems, either warning of intruders when there are none present (false positives) or failing to warn of intruders that are present (false negatives). The simplest systems available use passive infra red (PIR) detectors which use a staring detector or detectors sensitive to changes in thermal radiation. Such sensors detect intruders through the change in thermal radiation caused by an intruder entering the field of view of the detector. Such systems are very low cost but have a limited operating range (around 10m) and fail to detect very slowly moving intruders as the temperature change induced is too low.

More complex systems based on mechanically or electrically scanned microwave Doppler radar have been employed. Here intruders are detected by the Doppler shift induced by their motion. However, such systems are expensive and find it difficult to detect very slow moving or small targets such as a slowly crawling man. An example of such a system is the Plextek “Blighter” E-scan radar.

Video motion detection (VMD) based solutions are based on digitally processing the images of a scene captured by a video camera to look for changes in the image that may indicate the presence of an intruder. Whilst such systems are significantly cheaper than radar systems, they tend to suffer from a high level of false positives because it is difficult for the VMD image processing algorithms to distinguish between changes in an image due to an intruder and, for example, foliage moving in the wind or changes in the image due to weather or illumination conditions. This significantly reduces their effectiveness and increases running costs as a high level of human supervision and intervention is required.

Scanned laser radar systems have also been employed where a laser rangefinder is mechanically scanned across a region of interest. The laser rangefinder measures the distance from the scanner to the scanned point within the region of interest and thus allows the system to learn the topology of the region of interest. Once the topology has been learned, which typically takes several scans, the system is able to detect changes in the topology caused by the presence of intruders. However, to reliably detect the presence of an intruder requires the system to measure the topology with a high degree of accuracy and repeatability; typically in the region of centimetres. This increases the system cost due to the high precision needed in the mechanics of the scanner and the very high timing precision (fractions of a nanosecond) required to measure the topology. It also limits the scan rate to one scan every few seconds.

The limited scan rate makes it difficult to reliably detect fast moving intruders as they may only be detected in one scan, which could equally be caused by, for example, a bird flying into the region of interest. A further limitation is that these known systems are only able to detect the presence of the intruder, and cannot positively identify the intruder to determine whether the intruder is authorised or not to be in the region of interest (ROI). For many security applications this is a significant problem as is often a flow of authorised personnel/vehicles within the ROI and the task is to determine those intruders who are not authorised to be there.

There are a number of technologies which could potentially carry out such remote identification including biometric methods such as face or gait recognition, but these rely on very high quality images and high levels of processing power for successful operation which is costly. In addition such systems are relatively easy to defeat using simple means such as physical disguises.

Radio frequency identification devices (RFID) could also be used, but generally such devices have a short range and in any case require additional infrastructure to implement. In addition, for remote observation systems such as CCTV, there is always the difficult problem of positively and accurately correlating the detected intruder with a particular RFID within the ROI, particularly if there are more than 1 intruder detected.

According to a first aspect of the invention, there is provided an intruder detection system, comprising:

- an illumination means for illuminating a field of view with a modulated optical signal, modulated by a modulation signal;
- an optical receiver for receiving a delayed reflected signal;
- a cross correlator for calculating a cross correlation function between the modulation signal and the received delayed reflected signal; and
- means for detecting changes in the cross correlation function, a change being used to provide intruder detection.

This system uses optical sensing and cross correlation calculation to enable an intruder detection signal to be obtained. This can enable a solid state, low cost and reliable sensor to be provided for detecting intruders.

The cross correlation function effectively provides a map of reflectivities with distance. In particular, the cross correlation function will have peaks at times corresponding to distances at which objects are located, and the intensity of these peaks is representative of a reflectivity of the object. Thus, the system uses both the surface reflectivity and distance of remote objects to characterise a field of view.

The correlation function thus preferably comprises a series of correlation calculations for different time
shift values.

The means for detecting changes may comprise means for comparing the cross correlation function received with an average of previously received cross correlation functions. The use of an average cross correlation function enables the reference point to evolve, for example with changing lighting conditions. This also enables noise to be averaged out. A sudden change in the correlation function is detected by the detecting means.

A threshold detection means can be used for threshold detection within a difference signal between the cross correlation function and the average of previously received cross correlation functions. This is used to distinguish between an intruder and other changes in the field of view, for example changes outside a window.

The optical receiver can comprise an array of photodetectors, for example a photodiode array. This provides a low cost implementation.

Time of flight measurement circuitry can also be used for calculating a range to an intruder based on the detected changes in the cross correlation function.

The system may further comprise means for deriving a direction to an intruder from the cross correlation function. For example, the optical receiver can comprise a multi region photosensor array, and deriving a direction can be based on which region or regions of the detector result in the intruder detection signal.

This direction information can be used to control a direction of a camera. The range information can also be used to control the camera focus.

In a modification, the system further comprises an electronic tag for an authorised intruder, wherein the system is adapted to provide an alarm if a non-authorised intruder is detected, and not to provide an alarm if an authorised intruder is detected. This provides intruder identification as well as detection.

The tag can comprise a code generator and optical transmitter, for transmitting a modulated code signal in response to detection of the modulated optical signal. The tag preferably comprises means for synchronising the modulated code signal with the detected modulated optical signal, so that the signal can be received by the system with the reflected signal. The means for synchronising can comprise a tag cross correlator and a peak detector for deriving a synchronisation signal from the detected modulated optical signal.

A code can then be extracted from the signal received by the optical receiver which receives the delayed reflected signal. Thus, the main receiver of the system (as opposed to the tag) can simultaneously perform intruder detection based on the reflected signal, and intruder identification based on a modulated signal received with the reflected signal.

According to a second aspect of the invention, there is provided an intruder detection system comprising means for emitting a modulated signal and detecting a reflected signal from an intruder, and further comprising an electronic tag for an authorised intruder, wherein the system is adapted to provide an alarm if a non-authorised intruder is detected, and not to provide an alarm if an authorised intruder is detected. The tag is preferably adapted to detect the modulated signal and provide a signal in response which encodes electronic tag identification information.

The first aspect of the invention also provides a method of detecting an intruder, comprising:

- illuminating a field of view with a modulated optical signal, modulated by a modulation signal; receiving a delayed reflected signal;
- calculating a cross correlation function between the modulation signal and the received delayed reflected signal; and
- detecting changes in the cross correlation function, a change being used to provide intruder detection.

The method can also provide intruder identification in the same way as above, by providing an authorised intruder with an electronic tag, and providing an alarm if a non-authorised intruder is detected, and not providing an alarm if an authorised intruder is detected.

An example of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows a first example of system of the invention;
Figure 2 shows additional features to the system of Figure 1;
Figure 3 shows a tag for use in a second example of system of the invention;
Figure 4 shows how the system of invention is modified in the second example;
Figure 5 shows an example of circuit for generating a modulated code; and
Figure 6 is a timing diagram to explain the operation of the circuit of Figure 5.

In one aspect, the invention is based on the technology of optical range finding equipment, particularly using cross correlation calculations to detect peaks, for example for time of flight measurement.

EP 1 373 830 discloses an imaging system which scans a light source output over an object to be imaged, and receives the reflected signal in a multi-region light detector. The light source output is modulated, for example using a maximal length sequence. The time of flight of light signals from the light source to the actuated portion of the detector is calculated by cross correlation analysis for all scanning directions, to enable a three dimensional image of the object to be constructed.

This patent discloses the basic optical light source and detector technology which can be employed in the system of the invention.

EP 1 374 002 discloses a way of providing ef-
sufficient processing of cross correlation signals in a time of flight range finding application. A coarse cross-correlator and a fine cross-correlator can be used for coarsely and more accurately determining the time delay.

[0031] An aspect of the invention uses the technologies described in these documents.

[0032] Figure 1 shows an example of system of the invention.

[0033] A master oscillator 1 determines the sensor sampling frequency. Control electronics 2 generates a modulation signal 3 which is supplied to a modulated light source 4, which may be a laser or light emitting diode (LED) or array of lasers/LEDs with optics if necessary to illuminate the desired field of view.

[0034] The reflected received image from the field of view is focused by a lens 5 onto a detector array 6, comprising a multiplexed matrix of photosensitive detector elements (for example photodiodes).

[0035] A cross correlator 7 receives the original modulation signal 3 as well as the delayed reflected version, and computes in real time a cross correlation function.

[0036] This cross correlation function is determined for each region of the detector 6, for example photodiode or sub-array of photodiodes. The cross correlation function is a series of cross correlation values for different relative time shifts between the two signals. Any peaks in the function represent the presence of objects at a distance related to the time shift at which the peak occurs. The function can have multiple peaks, and the peak heights can be different as a result of different reflectivities.

[0037] An array of temporal averagers 9 average the cross correlation function from each selected detector element/group of elements over a defined time period. This provides a set of average cross correlation functions, which represent the field of view.

[0038] A subtractor 10 subtracts the real time cross correlation function (namely the one received at any point in time) from the averaged cross correlation function, and this generates a set of cross correlation functions which represent changes from the normal field of view, thereby representing intruders within the field of view.

[0039] Changes in the cross correlation function are thus used to provide an intruder detection signal.

[0040] A circuit block 11 computes the absolute value of the differences between the real time and the averaged cross correlation functions (as they may be negative), and the resulting difference functions are applied to a threshold detector 12 which is used to generate an intruder detection signal 14.

[0041] These components allow a detection signal to be generated.

[0042] The system also enables an intruder location to be determined.

[0043] If a particular detector element or group of elements is giving rise to the intruder detection, this will correspond to a particular sub-field of view. The controller 2 can thus provide an indication of the direction from the system to the intruder. This is represented as polar X and Y coordinate data. The distance to the intruder in that direction can be obtained by a time of flight computation circuit 13, which can operate in the same way as the earlier patent documents outlined above.

[0044] In operation, the modulated light source illuminates the region of interest with the modulated signal in optical form. In a preferred embodiment, the modulation signal is a pseudo random noise signal whose autocorrelation function is a delta function, although other signals such as a "chirp" may be used.

[0045] The lens focuses the modulated signal onto the multiplexed array. The control electronics controls the multiplexing of the photosensitive array to select either a single photodetector or group of photodetectors (the active photodetectors) and connect it/them to the cross correlator.

[0046] This independent actuation of photodetector elements enables the signal to noise ratio to be improved and is discussed in the references above. The cross correlator then computes the cross correlation function of the modulation signal with the signal detected by the active photodetectors.

[0047] This cross correlation function is effectively a map of the reflectivity versus range for the field of view focussed on the active photodetectors.

[0048] When the cross correlation function is input to the temporal averager, this acts to average successive cross correlation functions over time from that specific active photodetectors. One temporal averager is required for each of the active photodetectors to be used and each temporal averager must contain sufficient storage to store the complete cross correlation function averaged over an appropriate time period.

[0049] The temporal averager can be implemented in many ways, but one simple approach is to add a fraction (1/N) of the captured cross correlation function to (1 - 1/N) of the signal stored within the temporal averager. The temporal averager smooths out changes in the cross correlation function over time.

[0050] When the signal is subtracted from the "real time" cross-correlation function, any differences due to the presence of intruders are detected.

[0051] If an intruder is present then the sensor will provide an alarm signal. By carrying out a time of flight computation on the absolute difference signal, a depth (Z coordinate) of the intruder can be determined together with the polar X,Y coordinates of the intruder based on which photodetector of the detector array is active.

[0052] The subtraction of a temporally averaged signal removes any electrical and optical cross talk within the system, increasing system sensitivity.

[0053] The system can benefit from an oversampling approach to the modulation signal generation which allows sub-sample distance precision by computing the intersection of the best fit lines applied to the up and down slopes of the resulting signal (i.e. the signal applied to the threshold detector). This is described further in EP 1 252 535.
This example of the invention uses a map of reflectivities with distance, and thereby uses both the surface reflectivity and distance (which combined with the photodetector location in the focal plane gives the 3D physical location) of the features within the field of view.

In contrast, Lidar based solutions simply create a physical map of the surface profile within the sensor field of view and look for changes in that. This requires a very high degree of precision in depth measurement to detect small objects such as a crawling man.

Video motion detection solutions simply create a map of the intensities (due to reflectivity) within the sensor field of view and look for changes in that, without any additional depth information.

The sensitivity of the system described above to intruders, and resistance to false alarms, is determined by the level of spatial resolution, dependent on the number of photodetectors in the detector array (giving X, Y resolution accuracy), and the sampling clock frequency (giving Z resolution accuracy) and temporal averaging applied.

Because the sensor comprises an array of photodetectors it can also be used to capture an image of the intruder.

In addition, the intruder X,Y,Z information can be used to slew a high resolution camera to the correct location to capture a high resolution video or image of the intruder for intruder recognition purposes.

Figure 2 shows a camera 20 controlled by the arrangement shown in Figure 1, and the modified detector is shown in Figure 4.

The optical tag comprises the following elements, illustrated in Figure 3:

- a sensor 34 to detect a background modulation signal;
- a digital signal processor (performing the functions of the cross correlator 35, peak detector 38, and control and timing unit 31) which is used to carry out a cross correlation operation on the detected background signal to derive a correlation function 37 and extract a synchronisation signal 39 whose timing will be derived from and tightly linked to the detected background modulated signal;
- a code signal generator 40 which generates a second modulation signal whose modulation is phase linked to the synchronisation signal 39 and includes coded data; and
- an emitter 42 to transmit the second modulated signal.

Thus, it can be seen that the tag responds to an incoming modulation signal and emits a synchronised modulated signal of its own using a key code of the tag.

The intruder detector is modified compared to the arrangement shown in Figure 1, and the modified detector is shown in Figure 4.

An additional code extraction circuit 15 is provided, operating on the output of the cross correlator 35, and this enables an intruder code 16 to be determined.

In operation, when an intruder carrying a tag enters the region of interest (ROI), the sensor in the tag detects the background illumination. This signal is processed using the cross correlator 35 whose reference signal 36 has the same shape as the background modulation signal emitted by the intruder detector. However, as the tag and detector sensor are physically separate entities, there will be a timing difference between the signal emitted by the intruder detector (and captured by the tag’s sensor 34) and the reference signal generated within the optical tag and so the cross correlator will generate a correlation peak whose position in time represents this timing difference. The peak detector 38 is used to detect the position of the correlation peak. The fine/coarse cross correlation methodology described above and in EP 1 374 002 can be used to reduce the level of computation and also deliver sub-sample precision in the timing of this peak. A synchronisation signal 39 is generated by this process.

The synchronisation signal is fed into the code generation circuit 40 which because it is now synchronised with the background emission can generate a second modulation signal which contains a key code and is coherent, i.e. phase linked to the background modulation signal. This second modulation signal 41 is then emitted by the tag.
The intruder detector sensor detects the reflection from the intruder and computes the intruder’s position and range in the manner explained above.

[0073] However, the emission from the tag will also be focussed onto the intruder detector’s focal plane array and because it is emitted from the same position as the reflection from the intruder, will be detected by the same photodetector in the array.

[0074] When an intruder reflection is detected from a given photodiode, the associated code extraction circuit 15 is enabled which acts to extract any code in the detected signal. If the code is valid, then the intruder is classed as being authorised. Otherwise the intruder is considered to be unauthorised and an alarm is raised.

[0075] The code extractor may operate on the signal acquired from the photodiode and/or the cross-correlation signal depending upon the nature of the code emitted by the tag.

[0076] Regarding the coding, one simple method would be to use a time division multiplexed approach. In this case, the background modulation signal is configured to have “dead time” within it into which the tag may emit its coded signal. In this case, the code extractor will operate on the signal from the relevant photodiode directly.

[0077] A potential disadvantage of this approach is that the energy able to be emitted by the detector is reduced by the proportion of “dead time” allowed, which will limit the maximum range at which intruders can be detected. To overcome this disadvantage, more sophisticated schemes can be employed which take benefit from the precise synchronisation delivered by the cross correlator in the tag.

[0078] One such approach is explained with reference to Figure 5.

[0079] In Figure 5, the synchronisation signal 39 is used to synchronise a reference signal generator 50, whose output is connected to a series of phase shifters, each of which shifts the reference signal by a phase determined by a binary code generator 52. The outputs of the phase shifters are then added together and used to create the modulation signal 41.

[0080] When the intruder detector processes this signal, a cross correlation signal will be generated with several peaks. The first peak corresponds to the reflected signal of the intruder, whose time delay is determined by the time of flight and hence range of the intruder. The four peaks which follow have phase shifts relative to the first, reflected signal peak which allow the detector to extract the tag’s code. The series of peaks is shown in Figure 6.

[0081] This principle can be extended both by adding additional phase shifters and by changing the phase shifts over time to send more complex data from the tag to the detector.

[0082] This approach also allows the optical tag to operate with systems where the phase of the modulation signal is randomly varied to reduce intersystem crosstalk (as described in WO 2006/048604) as the tags cross-correlator output peak will track the modulation signal phase changes and hence automatically resynchronise the code signal phase.

[0083] Some examples of the system of the invention has been described, and there are many possible alternatives. The light source is preferably an LED array, although a laser light source may be used, and the output can be modulated by a maximal length sequence or other signal with a distinct autocorrelation function, such as a peak.

[0084] The light source can be stationary, with optics to illuminate the desired field of view, or else a scanning light source can be used.

[0085] The photosensor array is preferably a photodiode array, and this can be formed as a low cost IC. However, other optical sensors may be used such as CCDs.

[0086] The invention has been described as a collection of control blocks. It will be apparent to those skilled in the art that all of the data processing will be implemented by a computer program controlling a digital signal processor.

[0087] Various other modifications will be apparent to those skilled in the art.

Claims

1. An intruder detection system, comprising:

- an illumination means for illuminating a field of view with a modulated optical signal, modulated by a modulation signal;
- an optical receiver for receiving a delayed reflected signal;
- a cross correlator for calculating a cross correlation function between the modulation signal and the received delayed reflected signal; and
- means for detecting changes in the cross correlation function by comparing the cross correlation function received with an average of previously received cross correlation functions, a change being used to provide intruder detection.

2. A system as claimed in claim 1, wherein the correlation function comprises a series of correlation calculations for different time shift values.

3. A system as claimed in any preceding claim, wherein the optical receiver comprises an array of photodetectors, and the system preferably further comprises means for storing an image from the optical receiver.

4. A system as claimed in any preceding claim, further comprising time of flight measurement circuitry for calculating a range to an intruder based on the detected changes in the cross correlation function.
5. A system as claimed in any preceding claim, further comprising means for deriving a direction to an intruder from the cross correlation function, and preferably further comprising a camera and a controller for controlling a direction of the camera based on the derived direction.

6. A system as claimed in any preceding claim, further comprising an electronic tag for an authorised intruder, wherein the system is adapted to provide an alarm if a non-authorised intruder is detected, and not to provide an alarm if an authorised intruder is detected, the tag preferably comprising a code generator and optical transmitter, for transmitting a modulated code signal in response to detection of the modulated optical signal.

7. A system as claimed in claim 6, wherein the tag comprises means for synchronising the modulated code signal with the detected modulated optical signal, the means preferably comprising a tag cross correlator and a peak detector for deriving a synchronisation signal from the detected modulated optical signal.

8. A system as claimed in claim 6 or claim 7, further comprising means for extracting a code from the signal received by the optical receiver which receives the delayed reflected signal, said means preferably receiving the output from the system cross correlator.

9. An intruder detection system comprising means for emitting a modulated signal and detecting a reflected signal from an intruder, and further comprising an electronic tag for an authorised intruder, wherein the system is adapted to provide an alarm if a non-authorised intruder is detected, and not to provide an alarm if an authorised intruder is detected, wherein the tag is preferably adapted to detect the modulated signal and provide a signal in response which encodes electronic tag identification information.

10. A method of detecting an intruder, comprising:

- illuminating a field of view with a modulated optical signal, modulated by a modulation signal;
- receiving a delayed reflected signal;
- calculating a cross correlation function between the modulation signal and the received delayed reflected signal; and
- detecting changes in the cross correlation function by comparing the cross correlation function received with an average of previously received cross correlation functions, a change being used to provide intruder detection.

11. A method as claimed in claim 10, further comprising performing time of flight measurement to determine a range to an intruder based on the detected changes in the cross correlation function.

12. A method as claimed in any one of claims 18 to 21, further comprising deriving a direction to an intruder from the cross correlation function, and preferably further comprising controlling a direction of a camera based on the derived direction.

13. A method as claimed in any one of claims 10 to 12, further comprising providing an authorised intruder with an electronic tag, and providing an alarm if a non-authorised intruder is detected, and not providing an alarm if an authorised intruder is detected, the method preferably comprising, in the tag, transmitting a modulated code signal in response to detection of the modulated optical signal.

14. A computer program comprising computer program code means adapted to control a system as claimed in any one of claims 1 to 9 to perform all of the steps of any one of claims 10 to 13 when said program is run on a computer.

15. A computer program as claimed in claim 14 embodied on a computer readable medium.

Patentansprüche

1. Einbruchserkennungssystem, das Folgendes umfasst:

- ein Beleuchtungsmittel zum Beleuchten eines Sichtfeldes mit einem modulierten optischen Signal, moduliert durch ein Modulationssignal;
- einen optischen Empfänger zum Empfangen eines verzögerten reflektierten Signals;
- einen Querkorrelator zum Berechnen einer Querkorrelationsfunktion zwischen dem Modulationssignal und dem empfangenen verzögerten reflektierten Signal; und
- Mittel zum Erkennen von Änderungen in der Querkorrelationsfunktion durch Vergleich der empfangenen Querkorrelationsfunktion mit einem Durchschnitt von zuvor empfangenen Querkorrelationsfunktionen, wobei eine Änderung zum Ausgeben einer Einbruchserkennung benutzt wird.

2. System nach Anspruch 1, wobei die Korrelationsfunktion eine Reihe von Korrelationsberechnungen für unterschiedliche Zeitverschiebungswerte umfasst.

3. System nach einem der vorherigen Ansprüche, wo-
bei der optische Empfänger eine Anordnung von Fotodetektoren umfasst, und wobei das System vorzugsweise ferner Mittel zum Speichern eines Bildes von dem optischen Empfänger umfasst.

4. System nach einem der vorherigen Ansprüche, das ferner eine Laufzeitmessschaltung zum Berechnen einer Entfernung zu einem Eindringling auf der Basis der erkannten Änderungen in der Querkorrelationsfunktion umfasst.

5. System nach einem der vorherigen Ansprüche, das ferner Mittel zum Ableiten einer Richtung zu einem Eindringling von der Querkorrelationsfunktion umfasst und das ferner vorzugsweise eine Kamera und eine Steuerung zum Steuern einer Richtung der Kamera auf der Basis der abgeleiteten Richtung umfasst.


10. Verfahren zum Erkennen eines Einbruchs, das Folgendes beinhaltet:

   Beleuchten eines Sichtfeldes mit einem modulierten optischen Signal, moduliert durch ein Modulationssignal;
   Empfangen eines verzögerten reflektierten Signals;
   Berechnen einer Querkorrelationsfunktion zwischen dem Modulationssignal und dem empfangenen verzögerten reflektierten Signal; und
   Erkennen von Änderungen in der Querkorrelationsfunktion durch Vergleichen der empfangenen Querkorrelationsfunktion mit einem Durchschnitt von zuvor empfangenen Querkorrelationsfunktionen, wobei eine Änderung zum Ausgeben einer Einbruchserkennung benutzt wird.

11. Verfahren nach Anspruch 10, das ferner die Durchführung von Laufzeitmessungen zum Ermitteln einer Entfernung zu einem Eindringling auf der Basis der erkannten Änderungen in der Querkorrelationsfunktion beinhaltet.

12. Verfahren nach einem der Ansprüche 18 bis 21, das ferner das Ableiten einer Richtung zu einem Eindringling von der Querkorrelationsfunktion beinhaltet, und das ferner vorzugsweise das Steuern einer Richtung einer Kamera auf der Basis der abgeleiteten Richtung beinhaltet.


14. Computerprogramm, das Computerprogrammcode enthält, der so ausgelegt ist, dass er ein System nach einem der Ansprüche 1 bis 9 zum Ausführen aller Schritte nach einem der Ansprüche 10 bis 13 steuert, wenn das genannte Programm auf einem Computer abgearbeitet wird.

15. Computerprogramm nach Anspruch 14, ausgestaltet auf einem rechnerlesbaren Medium.
Revendications

1. Système de détection d'intrus, comprenant :
   un moyen d'illumination pour illuminer un champ de vision avec un signal optique modulé, modulé par un signal de modulation ;
   un récepteur optique pour recevoir un signal réfléchi temporisé ;
   un corrélateur croisé pour calculer une fonction de corrélation croisée entre le signal de modulation et le signal réfléchi temporisé reçu ; et
   un moyen de détection de changements dans la fonction de corrélation croisée en comparant la fonction de corrélation croisée reçue avec une moyenne de fonctions de corrélation croisée reçues précédemment, un changement étant utilisé pour fournir une détection d'intrus.

2. Système tel que revendiqué à la revendication 1, dans lequel la fonction de corrélation comprend une série de calculs de corrélation pour différentes valeurs de décalage temporel.

3. Système tel que revendiqué dans l'une quelconque des revendications précédentes, dans lequel le récepteur optique comprend un réseau de photodétecteurs, et le système comprend en outre de préférence un moyen de stockage d'une image depuis le récepteur optique.

4. Système tel que revendiqué dans l'une quelconque des revendications précédentes, comprenant en outre un montage de circuits de mesure du temps de vol pour calculer une distance jusqu'à un intrus en fonction des changements détectés dans la fonction de corrélation croisée.

5. Système tel que revendiqué dans l'une quelconque des revendications précédentes, comprenant en outre un moyen de dérivation d'une direction jusqu'à un intrus depuis la fonction de corrélation croisée, et de préférence comprenant en outre un appareil-photo et une unité de contrôle pour contrôler une direction de l'appareil-photo en fonction de la direction dérivée.

6. Système tel que revendiqué dans l'une quelconque des revendications précédentes, comprenant en outre un marqueur électronique pour un intrus autorisé, dans lequel le système est adapté pour fournir une alarme si un intrus non autorisé est détecté, et pour ne pas fournir d'alarme si un intrus autorisé est détecté, le marqueur comprenant de préférence un générateur de code et un émetteur optique, pour transmettre un signal de code modulé en réponse à une détection du signal optique modulé.

7. Système tel que revendiqué à la revendication 6, dans lequel le marqueur comprend un moyen de synchronisation du signal de code modulé avec le signal optique modulé détecté, le moyen comprenant de préférence un corrélateur croisé marqué et un détecteur de pics pour dériver un signal de synchronisation du signal optique modulé détecté.

8. Système tel que revendiqué à la revendication 6 ou à la revendication 7, comprenant en outre un moyen pour extraire un code du signal reçu par le récepteur optique qui reçoit le signal réfléchi temporisé, le débit moyen recevant de préférence les données de sortie du corrélateur croisé du système.

9. Système de détection d'intrus comprenant un moyen pour émettre un signal modulé et pour détecter un signal réfléchi d'un intrus, et comprenant en outre un marqueur électronique pour un intrus autorisé, dans lequel le système est adapté pour fournir une alarme si un intrus non autorisé est détecté et pour ne pas fournir d'alarme si un intrus autorisé est détecté, dans lequel le marqueur est de préférence adapté pour détecter le signal modulé et pour fournir un signal en réponse qui code l'information d'identification du marqueur électronique.

10. Procédé de détection d'un intrus, comprenant les étapes consistant à :
   illuminer un champ de vision avec un signal optique modulé, modulé par un signal de modulation ;
   recevoir un signal réfléchi temporisé ;
   calculer une fonction de corrélation croisée entre le signal de modulation et le signal réfléchi temporisé reçu ;
   détecter des changements dans la fonction de corrélation croisée en comparant la fonction de corrélation croisée reçue avec une moyenne de fonctions de corrélation croisée reçues précédemment, un changement étant utilisé pour fournir une détection d'intrus.

11. Procédé tel que revendiqué à la revendication 10, comprenant en outre l'étape consistant à réaliser une mesure de temps de vol pour déterminer une distance jusqu'à un intrus en fonction des changements détectés dans la fonction de corrélation croisée.

12. Procédé tel que revendiqué dans l'une quelconque des revendications 18 à 21, comprenant en outre l'étape consistant à dériver une direction jusqu'à un
intrus depuis une fonction de corrélation croisée, et comprenant en outre de préférence l’étape consistant à contrôler une direction d’un appareil-photo en fonction de la direction dérivée.

13. Procédé tel que revendiqué dans l’une quelconque des revendications 10 à 12, comprenant en outre l’étape consistant à fournir un marqueur électronique à un intrus autorisé, et fournir une alarme si un intrus non autorisé est détecté et ne pas fournir d’alarme si un intrus autorisé est détecté, le procédé comprenant de préférence l’étape consistant à transmettre, dans le marqueur, un signal de code modulé en réponse à une détection du signal optique modulé.

14. Programme informatique comprenant un moyen de code de programme informatique adapté pour contrôler un système tel que revendiqué dans l’une quelconque des revendications 1 à 9 pour réaliser toutes les étapes de l’une quelconque des revendications 10 à 13 quand ledit programme est exécuté sur un ordinateur.

15. Programme informatique tel que revendiqué à la revendication 14 inclus sur un support lisible par un ordinateur.
FIG. 2
Synchronisation Signal (39)

Reference Signal generator (50)

Phase shifter

Phase shifter

Modulation Signal including code (41)

Binary Code Generator (52)

\[ \phi_{\text{MSB}} \]

\[ \phi_1 \]

\[ \phi_2 \]

\[ \phi_{\text{LSB}} \]
REFERENCES CITED IN THE DESCRIPTION

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