

A SENSORY DEVICE FOR USE IN THE DETECTION AND EVALUATION OF OBJECTS.

FIELD OF THE INVENTION

The present invention relates to a device used in the detection of objects, assessment of objects detected and triggering sequences of actions. In particular, the invention is directed towards a device capable of detecting one or more objects; assessment of objects detected using extracted information such as location, measurements, identifying features and the subsequent triggering of one or more sequence of actions (**Figure 1**).

An example of such an application is in the use of the sensory device on the tracks of a rail or road system in daily operational usage. However, it will be appreciated that the device of the invention may be suitable for use in other appropriate scenarios where there is a three-stage process of firstly detection of objects, secondly assessment of objects and lastly triggering of pre-selected actions and no limitation is intended thereby.

BACKGROUND OF THE INVENTION

The adoption of a rail based transportation system with commuter platform is a common feature of modern society. Increasingly, the trend is towards minimizing the role of humans in the daily operation of the rail system; full automation being the ideal operational system.

This Sheet Has Been Replaced



THE DANGER

It is the nature of a rail based transportation system to involve the simultaneous movement of large masses of human traffic and cargo from elevated platforms of the rail station onto a train of cabins and vice versa whenever the cabins come to stop at predetermined stations. These trains are usually guided by rails or other means, however the invention is not limited to applications involving the guidance by rail.

The paths by which the train travels need to be monitored due to the inherent danger of undesired objects in the path of the train as it approaches or leaves the station. Such danger arises in the form of obstacles on the track in the path of the oncoming train (e.g. human trespassers, voluntary and otherwise, large animals, foreign objects and so on). The resulting collision between the oncoming train and obstacle leads to undesirable results; least of which is the disruption to the train schedule of the entire rail system and overall inconvenience for all commuters.

PRIOR ART

Typically, automated barriers are placed between the platform and the track to ensure that such accidents do not happen. An alternative to automated barriers is provided by this invention. Another approach is to deploy manpower to fulfill the function of monitoring the restricted areas and sounding an alarm if there is an exception. However, the deployment of manpower does not gel with the concept of a fully automated rail based transportation system.

Installation of pressure pads, attuned to predetermined range of weights, separating the platform from the track represents a possible solution (**Figure 2**). Typically, such a system would be de-activated as and when the scheduled train appears for the commuters to board/alight the train. However, such a solution suffers from high maintenance cost given the amount of traffic inevitably traversing between the platform and the train (on the tracks) daily.

Another possible consideration would be the installation of one or more light beams traversing the entire length of the platform from which a passenger could board the train. Referring to **Figure 3**, any interruption in the source beam to the receiver would ideally trigger the automatic safety maneuver of the oncoming train. Although such a solution would be ideal in terms of installation convenience and costs, it suffers from the fundamental flaw of non-selectivity in its triggering event. A casual swing of the arm of a commuter safely on the platform is as likely to cause a break in the source beam as that of a genuine case of a trespasser falling from the platform onto the track.

Yet another approach is the use of close circuit video cameras with motion detection features. However, this approach is not able to discriminate genuine trespasses to those motion caused by birds flying through the field of view of the camera or shadows casted by clouds or light reflections onto the detection zone or a commuter in partial obstruction of the camera (**Figure 4**).

Prior art detectors also detects fluctuation indiscriminately resulting in a high frequency of false alarms. An example of prior art detector is a close-circuit video camera that is able to represent the image it detects in an X-Y coordinate system (**Figure 5**).

Therefore an essential element of a practical solution to the stated danger must be the ability of the proposed system to assess and compute the degree of danger before an alarm is raised for genuine cases. The possibility of false alarms must be minimized if not eliminated. Still further, it is important to take into consideration that the rail based transportation system is frequently exposed (partial or otherwise) to environment elements (eg sunlight, rain): - the 'environmental ambient condition'. Such exposure increases the likelihood of false alarms in any solution incorporating sensory devices.

OBJECT OF THE INVENTION

It is therefore an object of the present invention to provide a sensory device able to detect one or more objects, assess the object or objects detected to determine whether a sequence of actions should be triggered. For instance to differentiate real dangers from environmental ambient conditions of a typical platform-based rail system.

SUMMARY OF THE INVENTION

The present invention consists of three (3) components:-

1. Directional Energy Emitting Source
2. Detector
3. Computational Apparatus

Directional Energy Emitting Source

This component of the present invention consists of a directional energy-emitting source directing energy towards the detector. The energy emitted can have frequencies ranging across the entirety of frequencies, can be a single frequency or a combination of frequencies. Examples of energy include infrared light, visible light, microwave, radio wave, ultrasound and so on. The energy emitted can be varying in intensity, varying in periodic or aperiodic pattern or varying in position along the energy-emitting source; or a permutation thereof.

An embodiment of such a directional energy-emitting source is a shapeable and continuous strip of one or two-dimensional discrete light emitting elements (LED) or eyelets emitting predetermined wavelengths of light. For instance, the use of an apparatus and method to provide custom lighting, US Patent 6,050,702 dated April 18th 2000 by Rahmonic Resources Pte Ltd. Such a device could also be shaped for placement into a complex three-dimensional pattern to create a desired effect (**Figure 6**).

It is preferred that that the directional energy-emitting source is a shapeable and continuous strip of one or two-dimensional continuous lighting elements emitting predetermined wavelengths of light; an example is the use of a lossy fibre (**Figure 7**). A lossy fibre is a continuous strip of optic fibre with intentional side emission characteristics. When energy is pumped into one or both ends of the optic fibre, this energy will emit continuously along the length of the optic fibre. A lossy fibre can also be shielded at desired positions to restrict the emission of light (forming “eyelets”), used in multiples of fibres and also placed in a complex three-dimensional pattern to create a desired effect.

Another alternate embodiment is the deployment of reflective patterns; for instance the use of painted checked-box patterns consisting of and not limited to black and white squares in place of a mechanical energy source (**Figure 8**). The paints or painted objects used in the creation of the black and white square pattern will be energy sensitive (not limited to visible light) in that ambient energy (e.g. sunlight, artificial light from fluorescent tubes) will be reflected to the detector (white squares) or absorbed (black squares).

Thereafter, from the point of view of the detector, an alternating checkered energy-reflecting strip is detected.

The selection of the light sensitive paints will be dependent on the wavelength/energy level of the energy source desired and tuned accordingly in the receiving detector. In cases where the ambient energy decreases (e.g. night-time, cloudy weather), an external and independent energy source is activated and acts as the alternative source of 'ambient energy' from which the checked box pattern of black and white squares feed on. Needless to say, the size of the individual squares of the checked box must be smaller than the smallest object intended to be detected in the detection zone.

An essential feature of the invention is that more than one energy emitting light source of the same type or a combination of different energy emitting light sources can be used. Another feature is that the energy emitting light source can be connected to the other components of the invention to form a closed loop system (**Figure 1**). For instance, the detector or computational device can increase or decrease the energy intensity of the energy emitting light source and so on.

Another essential feature of the directional energy-emitting device is the optional use of the shroud. The function of the shroud is to act as a hood for the source and to ensure that only energy directed at the detector from certain directions will be received and accepted. The shroud achieves this by absorbing ambient energy (eg from the sun or street lamp) hitting the exterior of the shroud and prevents ambient energy from entering into the

shroud. As such, the detector will detect only energy that is radiating from the energy source.

Conversely, similar energy from other non-designated sources hitting the detector will be ignored as they do not come from a pre-designated direction from the shrouded directional energy emitting source. For example, it is preferred that energy with the same infrared signature but unauthorized source will be rejected (**Figure 9a**). The shroud need not necessarily be part of the energy emitting source and in one method of embodiment, is actually part of the infrastructure upon which this present invention is to be employed (**Figure 9b**). Another example of a shroud is louvres or venetian blinds which only allows light to pass through from certain directions e.g. 3M™ Microlouvres.

The geometric placement or geometric pattern of placement of the shapeable energy-emitting source is crucial to the success of the invention and is an integral portion of the invention; just as the geometric placement or geometric pattern of placement of the detector or detectors (to be discussed later) is crucial to the success of the invention and also an integral portion of the invention.

From each energy-radiating path of the lossy fibre, a continuous source beam is emitted, thereby continuously sweeping across the detection zone. In its preferred embodiment, the geometric placement of the directional energy emitting source is three-dimensional to cover more than one possible avenues of trespass to the detection zone (**Figure 10**). In its preferred embodiment, a light source in the spectrum of infrared is adopted, thus

distinguishing the energy emitted from all visible light. It is preferred that the placement of the energy transmitting source(s) is placed before any object trespasses into the detection zone. A safety margin will be predetermined before the alarm for real dangers is sounded. The placement of the source in a geometric pattern will also eliminate random interferences like flailing arms of commuters safely on the platform and birds flying momentarily through the detection zone triggering a false alarm.

Detector

The invention utilises one or more detectors (Figure 1) and each detector is perceived to be an emitted energy detector with optional signal processing capabilities. In normal use, the detector is positioned to face the energy emitting source.

With regard to the mechanism of detection, any object that interferes with the transmission of energy to the detector would be deemed as detected (Figures 1 and 11) and object information can be extracted by the detector itself. Alternatively, object information can be extracted by the computation device or by both the detector and the computational device.

The detector in this invention has an added feature whereby an infrared filter can be attached to the detector. When used with an infrared energy emitting source, the infrared filter blocks out all other background images (including humans) leaving only the reception of the desired image (Figure 11b). Although any random infrared energy source may also be detected by the detector, the invention uses the computation device to remove these random source detection.

This is to be compared against the image received from a conventional detector (eg a close-circuit television) (**Figure 5**), which would have distracting background images irrelevant to the detection of trespassers to the detection zone. From the figure, it can be seen that a 'breakage' arises when there is an obstruction between the energy emitting source and the detector. It is possible to have more than one breakage and of varying sizes of breakages (**Figure 11b**).

Another feature of the detector in this invention is that the detector can either function independently or in close loop control with the energy emitting source or the computational device or both.

Computational Device

It is preferred that the computational device is a device to process the data received by the detector and subsequently communicate with the energy emitting source and detector if necessary (**Figure 1**). The manner of computing would be dependent upon the interruption in one or more of the multiple source beams bisecting any position of the energy emitting source and the detector (**Figures 10 and 11**). The computational device is also capable of extracting object information from these interruptions or breakages in the energy emitted by the energy emitting source towards the detector. **Figure 12** shows the manner of computing for the computational device.

Whereas most prior art apparatus would trigger an action the instance a breakage is detected, this invention utilises Implicit temporal computation characteristics whereby time is one of the characteristic in determining whether an action should be triggered. For instance, length of time of breakage, pattern of breakage, time of maintenance event and so on (Table 1).

The preferred end result of the entire interaction between all 3 components, starting from the detection of the interruption would be the extraction of object information to determination of the following characteristics of the triggering object or objects:-

Table 1

	Implicit		Explicit
A	Position of Breakage	A	Time of Event (eg maintenance period)
B	Size of Breakage	B	Bypass (eg manual disable)
C	Length of Time of Breakage	C	Over-ride (eg by other sensors or computational device)
D	Pattern of Breakage	D	External trigger
E	Nature of Breakage	E	Any other Explicit characteristics and so on
F	Frequency of Breakage		
G	Any other Characteristics of Breakage		
H	Any other Implicit		

	characteristics and so on		
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Implicit characteristics refer to characteristics that are obtained from the data that is extracted from the obstruction between the energy emitting source and the detector. Explicit characteristics are characteristics, which are external to the computational device but has an impact on the detection of the object in the detection zone of the rail station and the assessment of the danger posed by the object.

An essential feature of the computational device is its ability to learn one or more parameters by which one or more characteristics of the detected objects can be compared against. The invention can be taught by a human operator or another machine the parameters of what is acceptable before certain consequential actions are performed. For instance, **Figure 12 Line 2, LABEL A: IF OP(TEACH) THEN action.**

Teaching and data entry can be done using any data input mechanism such as a keyboard, trackball, touchscreen, joystick, mouse and by remote networking or wireless means. Besides the input mechanism, the computational device can optionally contain an output display mechanism such as a video monitor. For instance, the position of a source of energy being emitted can be programmed to be ignored or to be registered as 'important' (**Figure 12, Line 6-15**), thereby teaching the present invention to recognize only energy from pre-determined sources..

The invention can also be taught the size of the breakage triggering the alarm to acknowledge only 'real' dangers. For example, **IF (size of**

breakage) > 12, THEN ALARM, where 'size of breakage' is an implicit characteristic, '12' is a taught or calibrated parameter, '>' is an OP logic operation, and 'ALARM' is a consequential action that sounds the alarm.

Another example is to 'teach' the computational device to complement the train schedule of the individual rail stations; thereby 'ignoring' the breakage caused by the incoming train as it approaches the rail stations. For example, **IF (train entering station) THEN SUPPRESS_ALARM**, where 'train entering station' is an explicit characteristic and 'SUPPRESS_ALARM' the consequential action. In its preferred embodiment, the prediction and assessment of the point of impact between the obstacle and the oncoming train will be made available by the computational device by taking into account the distance between the obstacle and the train and the speed of the train.

The computational device can also be taught to communicate with more than one energy emitting sources and detectors from which three-dimensional information of the object detected is obtained using simple trigonometry. For instance, an object the size of a cigarette package would be considered too small to sound an alarm.

Another essential feature of the computational device is its ability to be calibrated (**Figure 12, Line 3**). Calibration of the computational device enables the translation of the data extracted by the detectors into meaningful information. An example would be the nature of the breakage(s) being translated into physical dimension eg length of object detected. This can be done by placing an object of known dimensions in front of the energy

emitting source thereby creating a breakage and equating the size/nature of the breakage to the known dimensions.

The operation of the computational device can take the form of a sequence of steps such as System Initialization (Figure 12, Line 1), Teaching (Figure 12, Line 2), Calibration (Figure 12, Line 3), Object Information Extraction (Figure 12, Lines 4), Rules (Figure 12, Line 6-15) and Actions (Figure 12, Line 18) . An example of an Action is to sound an alarm or to stop the train. Another example of an Action is to provide the data highlighting the area of breakage by drawing a box on a display monitor with the screen co-ordinates (x1, y1) and (x2, y2).

With the invention, the exact functional sequence of operation need not be followed if the permutation of the sequence still achieves the final outcome. For instance, the steps of calibration and teaching are interchangeable in sequence. That is, teaching can be performed before calibration.

Furthermore, if a step has been completed and unchanged, the information related to the step can be saved and recalled later for reuse. Such steps may include setup, calibration and teaching for example.

The exact dimensions of each component of the invention are not significant provided that the functional objectives of the component and the invention are met. Similarly, the placement of the components or the location of the features of each component is not essential provided that the functional objectives of the component and the invention are met.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows the preferred set-up of the present invention with all 3 components ie the energy emitting device, the detector and the computational device

Figure 2 shows the use of pressure pads in a platform-based rail system

Figure 3 shows the use of light fence detector in a platform-based rail system.

Figure 4 shows the use of close circuit video cameras with motion detection features in a platform-based rail system. In addition, the inherent difficulties presented by the ambient conditions surrounding a platform-based system are shown.

Figure 5 shows the image received and seen from a conventional close circuit monitor with unnecessary background clutter.

Figure 6a shows a long rigid energy emitting source in two rows either jointed or separated. **Figure 6b** shows the three dimensional malleability desired in the directional energy emitting source of the present invention.

Figure 7 compares a conventional optic fibre with negligible side emission (**Figure 7a**) against a lossy fibre with continuous side emission (**Figure 7b**).

Figure 8 illustrates the checkered paint strip with alternating black and white boxes as another embodiment of the energy emitting device.

Figure 9 is a diagram illustrating the field of view of the detector; accepting directed energy from pre-selected energy emitting source(s) with a shroud (**Figure 9a**). In **Figure 9b**, it is shown how a concrete infrastructure is used as the shroud for the detector.

Figure 10 shows the preferred geometric placement of the directional energy emitting source in three-dimensional format to cover more than one possible avenues of trespass into the detection zone of the rail system

Figure 11 shows the image of 'breakage' received and seen by a conventional close circuit monitor (**Figure 11a**) as compared to the employment of an infra-red filter with the detector (**Figure 11b**).

Figure 12 is an example of a sequence of steps adopted in the operation of the computational device as shown by the line numbers. Where the definition of the sequence of steps are also explained.

CLAIMS

1. An apparatus for use in detecting and evaluating one or more objects to determine consequential action or actions comprising of three parts A), B) and C) where :-

A)

Either

one or more directional energy emitting device (1a) whereby the directional emitting source is a one, two or three-dimensional shapeable and continuous strip of lighting elements (6);

or

one or more directional energy emitting device (1a) whereby the directional energy emitting source, such as a laser, is pumped through a one, two or three-dimensional shapeable and continuous lossy fibre with side emission capabilities (7);

or

one or more multi-directional energy emitting device (1a) whereby the deployment of reflective one, two or three-dimensional patterns of light sensitive paints or painted objects of differing colours reflecting ambient light (8)

or a combination of the above,

and



- B) one or more detector device (1b) whereby the interference in the transmission of energy from the energy emitting device to the detector registers one or more objects between the energy emitting device and the detector (11)

and

- C) one or more computational device (1c) whereby the computational device can analyse the data derived from the objects registered by the detector (11)

2. A method claim whereby the detecting and evaluating of one or more objects to determine the consequential action or actions, comprising of an apparatus (1, 6,7,8,9,10,11) as claimed in claim 1, which uses one or more energy emitting device of the same or different type in conjunction with one or more detector device and one or more computational device computing with a certain manner of computation (12).
3. A method according to any of the preceding method claims whereby the energy emitted by the energy emitting device is directional and capable of adopting energy of various frequencies; single or a combination of frequencies either functioning independently or in closed loop control with the detector or computational device or both by wired or wireless means.



4. A method according to any of the preceding method claims whereby the energy emitted by the energy emitting device is of varying intensities from periodic to aperiodic pattern or varying in position along the energy emitting source either functioning independently or in closed loop control with the detector or computational device or both by wired or wireless means.
5. An apparatus according to any of the preceding apparatus claims whereby a shroud (9a) directs the energy emitted to the receiving detector, while preventing interfering random energy to be emitted to the receiving detector, and is used either independently or as part of the infrastructure (9b) of the site.
6. A method according to any of the preceding method claims whereby an optional shroud (9a) directs the energy emitted to the receiving detector, while preventing interfering random energy to be emitted to the receiving detector, and is used either independently or as part of the infrastructure (9b) of the site.
7. An apparatus according to any of the preceding apparatus claims whereby the coverage of the detection zone is a one dimensional, two dimensional or three dimensional energy emitting device (1,6,7,8) to capture one or more possible avenues of trespass into the detection zone.
8. A method according to any of the preceding method claims whereby one dimensional, two dimensional or three dimensional geometric



patterns of placement of the energy emitting device (1,6,7,8) enables the scope of detection to encompass the possible avenues of trespass into the detection zone

9. An apparatus according to any of the preceding apparatus claims whereby the computational device (1c) either functions independently or in closed loop control with the energy emitting source (1a) or detector (1b) or both by wired or wireless means.
10. A method according to any of the preceding method claims whereby the computational device (1c) either functions independently or in a closed loop control with the energy emitting source (1a) or detector (1b) or both by wired or wireless means.
11. An apparatus according to any of the preceding apparatus claims whereby either the detector device or computational device or both extracts object information from the breakage of emitting energy from the energy emitting device (10,11).
12. A method accordingly to any of the preceding method claims whereby either the detector device or the computational device or both extracts object information from the breakage of emitting energy from the energy emitting device (10,11).
13. An apparatus according to any of the preceding apparatus claims whereby the detector can be used with or without an emitted energy filter to allow only certain energy to be detected by the detector.



14. A method accordingly to any of the preceding method claims whereby the detector can be used with or without an emitted energy filter to allow only certain energy to be detected by the detector.
15. An apparatus according to any of the preceding apparatus claims whereby the computational device extracts object information or data received by the detector and other external sources and turning them into Implicit or Explicit characteristics.
16. A method accordingly to any of the preceding method claims whereby the computational device extracts object information or data received by the detector and other external sources and turning them into Implicit and Explicit characteristics.
17. An apparatus according to any of the preceding apparatus claims whereby the computational device can be taught with the use of a data input mechanism one or more parameters by which one or more Implicit and Explicit characteristics can be compared against before consequential actions are performed.
18. A method accordingly to any of the preceding method claims whereby the computational device can be taught with the use of a data input mechanism one or more parameters by which one or more Implicit and Explicit Characteristics can be compared against before consequential actions are performed.



19. An apparatus according to any of the preceding apparatus claims whereby the computational device can be calibrated to enable the translation of the data extracted by the detector or computational device into corresponding meaningful information.
20. A method according to any of the preceding method claims whereby the computational device can be calibrated to enable the translation of the data extracted by the detector or computational device into corresponding meaningful information.
21. An apparatus according to any of the preceding apparatus claims whereby the computational device utilises temporal information in parameters and characteristics, for instance the length of time of breakage (Implicit characteristic) and time of event (Explicit characteristic) and so on.
22. A method according to any of the preceding method claims whereby the computational device utilises temporal information in parameters and characteristics, for instance the length of time of breakage (Implicit characteristic) and time of event (Explicit characteristics) and so on.
23. An apparatus according to any of the preceding apparatus claims whereby the computational device utilises 'If', 'Then' action sequence or sequences or permutation thereof to enable to evaluation of the detected object or objects and hence determining the consequential action.



24. A method accordingly to any of the preceding method claims whereby the computational device utilises 'If', 'Then' action sequence or sequences or permutation thereof to enable the evaluation of the detected object or objects and hence determining the consequential action.
25. An apparatus according to any of the preceding apparatus claims whereby the control flow of the computational device perform the functions of Initialise, Teach, Calibrate, Extract Object Information , 'If', 'Then' operations ending with an Action or control flow, and not limited to the sequence which results in the same effect (12).
26. A method according to any of the preceding method claims whereby the control flow of the computational device perform the functions of Initialise, Teach, Calibrate, Extract Object Information, 'If', 'Then' operations ending with an Action or control flow, and not limited to the sequence which results in the same effect (12).
27. An apparatus according to any of the preceding apparatus claims whereby the control flow of the computational device takes the form of **Figure 12**.
28. A method according to any of the preceding method claims whereby the control flow of the computational device takes the form of **Figure 12**.



29. A method according to any of the preceding method claims whereby the computational device (1c) assess the likelihood of collision using information extracted as characteristics and prevent the collision of an object (e.g. incoming train) and another object in the detection zone (e.g. track within a train station) using consequential actions performed by the computational device.
30. An apparatus according to any of the preceding apparatus claims whereby the computational device as a consequential action of using one or more parameters or characteristics or other information, displays on the computational device the object or objects detected.
31. A method according to any of the preceding method claims whereby the computational device as a consequential action of using one or more parameters or characteristics or other information, displays on the computational device the object or objects detected.
32. An apparatus according to any of the preceding apparatus claims whereby the computations device (1c) reduces the likelihood of false results or alarms due to random interference.
33. A method claim according to any of the preceding method claims whereby the computation device (1c) reduces the likelihood of false results or alarms due to random interference.

