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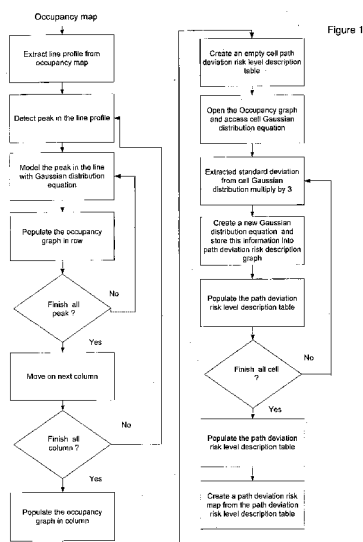
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(54) Title: A METHOD OF RISK MODEL DEVELOPMENT



(57) Abstract: A method of risk model development is provided where the method includes the steps of extracting a line profile from an occupancy map, detecting peaks in the line profile, modeling the peak inline with Gaussian distributing equation, populating an occupancy graph by rows and columns, calculating a path deviation risk table and generating a path deviation risk map from the risk table.

A METHOD OF RISK MODEL DEVELOPMENT

FIELD OF INVENTION

- 5 The present invention relates to a method of risk model development, more particularly relates to a method of developing a risk model and using said model to determine safe zones of a system.

BACKGROUND OF INVENTION

10

Complex behaviors are difficult to detect and this is one of the key issues in current surveillance applications. It is a challenge to detect a subject's behavior that has been recorded from a surveillance application. Using a simple solution based on hit or miss method, a subject is considered to be behaving suspiciously as long as said subject
15 starts deviating from the main or the reference path. This method does not provide satisfactory results as a subject may not necessarily be a suspect as this method will possibly create a significant amount of false alarms.

Subject behavior databases may usually be procured using standard machine learning
20 or any artificial intelligence methods. However, it is the efficient utilization of this data that will guarantee accuracy of prediction.

U.S. 6441734 describes a security monitoring system that records and compares trajectory information of an individual's path against known trajectories. However, the
25 downfall of this method is that its comparing capabilities are able to only produce binary results where an individuals' path is deduced to be suspicious or non-suspicious.

U.S. 7127083 describes yet another video surveillance system that uses rule-based reasoning and multiple-hypothesis scoring to detect predefined behaviors based on an individual's movement. Unfortunately, this system is based on the assumption that the hypothesis made is accurate where a faulty assumption such as criteria of size may
5 skew the results of the detection.

Therefore, there exists a need in the field to produce a reliable method of detection and determining a subjects' complex behavior from a surveillance system.

SUMMARY OF INVENTION

Accordingly there is provided a method of risk model development, the method includes the steps of extracting a line profile from an occupancy map, detecting peaks
5 in the line profile, modeling the peak inline with Gaussian distributing equation, populating an occupancy graph by rows and columns, calculating a path deviation risk table and generating a path deviation risk map from the risk table.

There is also provided a method of determining safe zones from a risk model, the
10 model includes the steps of detecting tracking data from input devices, comparing data with a risk model in a provided database and verifying tracked data is within a predefined safety zone.

There is further provided a method of determining safe zones from a risk model, the
15 method includes the steps of detecting tracking data from input devices, comparing data with a risk model in a provided database, retrieving confidence levels of tracking data from the risk model, comparing confidence levels with predefined danger levels, triggering an alarm if danger levels are higher than predefined danger levels, comparing confidence levels with predefined warning levels and alerting security if
20 warning levels are higher than the predefined warning levels.

The present invention consists of several novel features and a combination of parts hereinafter fully described and illustrated in the accompanying description and drawings, it being understood that various changes in the details may be made without
25 departing from the scope of the invention or sacrificing any of the advantages of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be fully understood from the detailed description given herein below and the accompanying drawings which are given by way of illustration only, and
5 thus are not limitative of the present invention, wherein:

Figure 1 is a flowchart showing the steps taken in developing a risk model;

Figure 2 is a diagram illustrating a contour plot of a multiple Gaussian distribution and its corresponding cross-sectional view;

Figure 3 is a diagram illustrating a 3 dimensional view of a surface map with multiple
10 Gaussian distributions;

Figure 4 is a diagram illustrating an original Gaussian distribution and a converted Gaussian distribution and their respective standard deviation graphs;

Figure 5 is a diagram illustrating an effect of changing standard deviation of a Gaussian distribution;

15 Figure 6 is a diagram illustrating a 3 dimensional view of a final path deviation risk map with an extended risk distribution in an embodiment of the present invention;

Figure 7 is a flowchart showing the steps taken in determining safe zones using a path deviation risk map;

Figure 8 is a diagram illustrating zone distribution for safe levels, warning levels and
20 danger levels in an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention relates to a method of developing a risk model and using said model to determine safe zones of a system. A detailed description of preferred
5 embodiments of the invention is disclosed herein. It should be understood, however, that the disclosed preferred embodiments are merely exemplary of the invention, which may be embodied in various forms. Therefore, the details disclosed herein are not to be interpreted as limiting, but merely as the basis for the claims and for teaching one skilled in the art of the invention.

10

The following detailed description of the preferred embodiment will now be described in accordance with the attached drawings, either individually or in combination.

While the following description may describe example embodiments of the present
15 invention in relation to surveillance systems, the invention is not limited to and can be applicable to other types of risk model development where similar advantages may be obtained. Such risk models for which inventive embodiments may be applicable specifically include, financial and medical applications.

20 Occupancy maps are obtained from databases wherein these databases are built from standard paths or reference paths of subjects in a scene that are learned through machine learning or any existing artificial intelligence methods. The occupancy map is built by plotting frequency of occurrence against coordinates. In order to produce a reliable database, the occupancy map is built over a long period of time so as to
25 capture a sample that is as close as possible to an actual population that is being sampled.

In order to define suspicious and non-suspicious behavior, risk levels are assessed to produce a reliable model since the analysis of human behavior is a complex exercise. This invention discloses a method of developing a risk model to assess suspicious behavior of subjects in a surveillance system.

5

Figure 1 illustrates the steps of developing a risk model. The occupancy map produced from long term learning through a machine learning technique such as a neural network is used as a starting point for this analysis. The occupancy map can be described as a multiple Gaussian distribution on a 2-dimensional surface map. The contour plot of the multiple Gaussian distribution and its corresponding cross-sectional view is shown in Figure 2. The method as shown in Figure 1 begins with extracting a line profile from the occupancy map. The peaks in said line profile are detected. The cross-sectional view of the Gaussian distribution shows a line profile according to the location in the map with respect to the scene. The peaks from the line profile are then modeled in Gaussian and standard deviation is calculated for each point of the entire cross-sectional Gaussian distributions.

All Gaussian distributions are first identified and stored in memory. Standard deviation values for each of the Gaussian distributions are identified and the distribution is then transformed using the formula below:

20

$$f(x) = \frac{e^{-(x-\mu)^2/(2\sigma^2)}}{\sigma\sqrt{2\pi}}$$

Where

25 μ = mean and σ = standard deviation.

The Gaussian distributions are then used to populate an occupancy graph. Some line profiles in the Gaussian distribution have more than 1 peak. When this occurs, the peaks are placed in the occupancy graph based on the order of which they appear in said Gaussian distributions as seen in Table 1.

5

Column number	Peak number			
	1 st	2 nd	3 rd	n th
1	(Mean, standard deviation)	(Mean, standard deviation)		

Table 1

10

These steps are repeated until all line profiles are extracted and the Gaussian distribution is used to calculate a two dimensional path deviation risk table as shown in Table 2.

Column Number	Peak Number			
	1 st	2nd	3rd	n th
1	(Mean, standard deviation)	(Mean, standard deviation)		
2	(Mean, standard deviation)	(Mean, standard deviation)		
3	(Mean, standard deviation)			
4	(Mean, standard deviation)	(Mean, standard deviation)	(Mean, standard deviation)	(Mean, standard deviation)
N				

Table 2

This risk table is a numerical representation of the original occupancy map. A cross
 5 section of the Gaussian distribution shows a frequency profile according to the location
 in a map (as seen in Figure 2) with respect to the scene. Figure 3 shows a 3
 dimensional view of a surface map where X axis and Y axis denote a coordinate of a
 plot and Z axis denotes number of occurrences at that particular point.

10 In order to use a normal distribution model more efficiently, it is deduced that the
 modeling of the normal distribution against the standard path cannot accurately

represent the true scenario of subjects' path in the scene. It is disclosed in this invention that the normal distribution built from an occupancy map is modified in order to produce confidence level information when suspicious behavior is detected. An empty path deviation risk graph is created. A conversion procedure is conducted on every cell in the original occupancy map. The conversion is described as multiplying the standard deviation in the original occupancy map by a predetermined factor, such as 3. The resulting value, which is a new standard deviation value, is replaced into the original equation wherein the newly created Gaussian equation is used to populate the created empty path deviation risk graph as shown in Table 3.

10

Column Number	Peak Number			
	1 st	2nd	3rd	n th
1				
2				
3				
4				
N				

Table 3

Therefore, the new equation features the following condition:

$$1 \sigma \text{ in the new distribution} = 3 \sigma \text{ opening in the original distribution}$$

15

where σ = standard deviation value.

With this condition applied to the Gaussian equation, 99.54 % of the original distribution from the original equation now uses 1 standard deviation (σ) of the new path deviation

risk graph. Figure 4 shows both the original and new Gaussian distributions and their respective σ distribution graphs. In order to produce a meaningful detection mechanism, the original 3σ distribution is matched to the new 1σ distribution in the newly created Gaussian distribution. Doing this would open up the dispersion of the distribution. This creates an extended continuous risk distribution as the newly created Gaussian distribution. This is to ensure that we do not obtain a binary result such as a yes or no answer. An effect of changing the standard deviation to a value of 3σ from the original standard deviation of Gaussian distribution of 1σ can be seen in Figure 5. A 3 dimensional view of the final path deviation risk map with the extended risk distribution that has been generated from the completed risk table of Table 3 can be seen in Figure 6.

The new final path deviation risk map can be used to detect suspicious and non-suspicious behavior in terms of path deviation in a system. For example, in this embodiment of the invention, the risk map created can be used in a surveillance system. Figure 7 depicts a method of determining safe zones using the path deviation risk map. The surveillance system detects tracking information and compares this information with the risk model in a previously stored database. If the tracked information is within a predefined safe zone, the process ends at this point as it is verified as within a safe zone. However, if the tracked information is not within the safe zone, confidence level of the tracked object will be retrieved from the risk model. This confidence levels are then compared with the predefined danger levels. If the risk level is found to be insignificant, the tracked object will then be compared with predefined warning levels instead. If the warning level is found to be insignificant as well, the tracked object data will be passed back to main detection mode. However, if the warning levels are found to be sufficiently above the predefined levels, security personnel will be alerted of the warning levels. Similarly, if danger levels are found to

be sufficiently above the predefined levels, an alarm will be sounded to signify the danger levels. Figure 8 illustrates zone distribution for safe levels, warning levels and danger levels as described. The action that is assigned as a warning level and danger level can be determined by user and the actions described here are not limitative as

5 these actions can be defined by users as required.

CLAIMS

1. A method of risk model development, the method includes the steps of:
 - i. extracting a line profile from an occupancy map;
 - ii. detecting peaks in the line profile;
 - 5 iii. modeling the peak inline with Gaussian distributing equation;
 - iv. populating an occupancy graph by rows and columns;
 - v. calculating a path deviation risk table; and
 - vi. generating a path deviation risk map from the risk table.
- 10 2. The method as claimed in claim 1, wherein the occupancy map is derived from machine learning systems or existing artificial intelligence methods.
3. The method as claimed in claim 1, wherein the generated risk map is used as a new risk model database.
- 15 4. The method as claimed in claim 1, wherein the calculation of path deviation risk table is done by conducting a conversion procedure on cells in the occupancy map wherein the conversion is multiplication of standard deviation in original occupancy map by a predetermined factor.
- 20 5. The method as claimed in claim 1, wherein the generation of a path deviation risk map is done by replacing the new standard deviation value into the original Gaussian distribution equation to create a new Gaussian equation.
- 25 6. A method of determining safe zones from a risk model, the model includes the steps of:
 - i. detecting tracking data from input devices;

- ii. comparing data with a risk model in a provided database; and
- iii. verifying tracked data is within a predefined safety zone.

7. A method of determining safe zones from a risk model, the method includes the
5 steps of:

- i. detecting tracking data from input devices;
- ii. comparing data with a risk model in a provided database;
- iii. retrieving confidence levels of tracking data from the risk model;
- iv. comparing confidence levels with predefined danger levels;
- 10 v. triggering an alarm if danger levels are higher than predefined danger levels;
- vi. comparing confidence levels with predefined warning levels; and
- vii. alerting security if warning levels are higher than the predefined warning levels.

15

8. The method as claimed in claim 6 and 7, wherein the input devices are imaging devices, such as cameras.

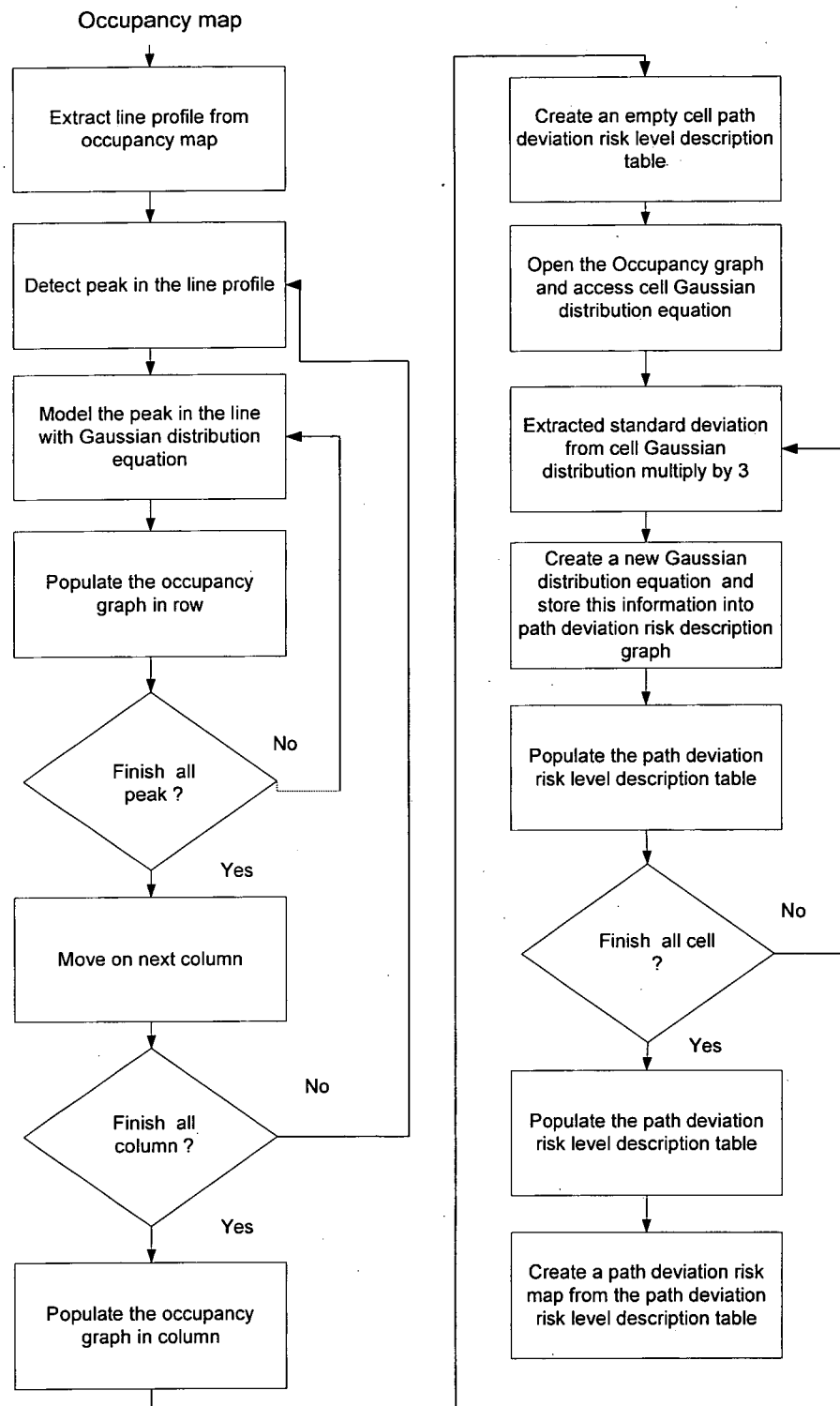


Figure 1

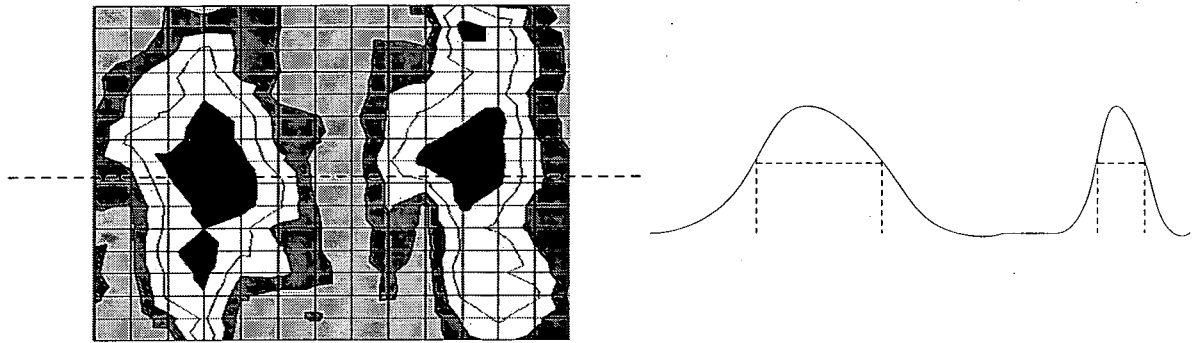


Figure 2

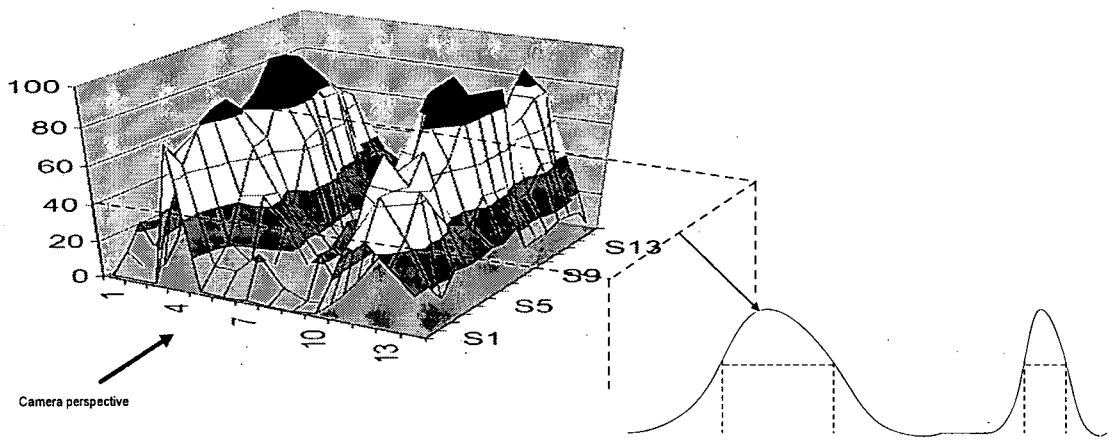


Figure 3

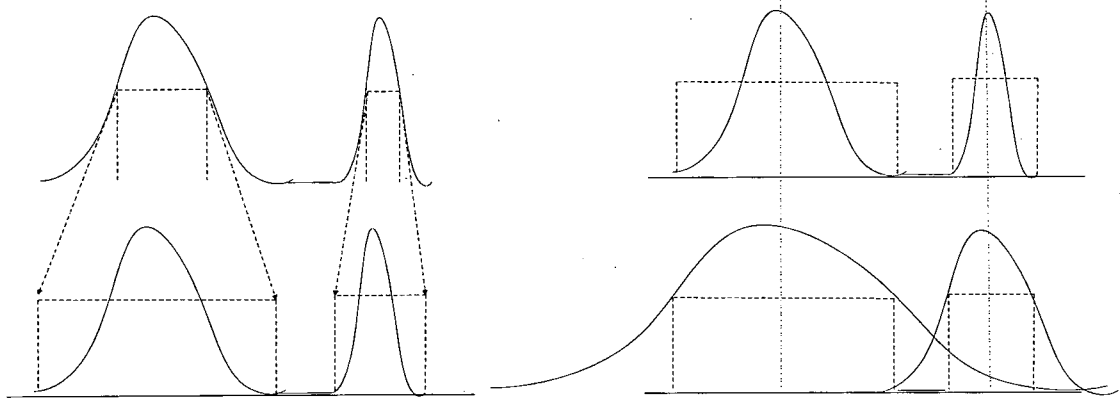


Figure 4

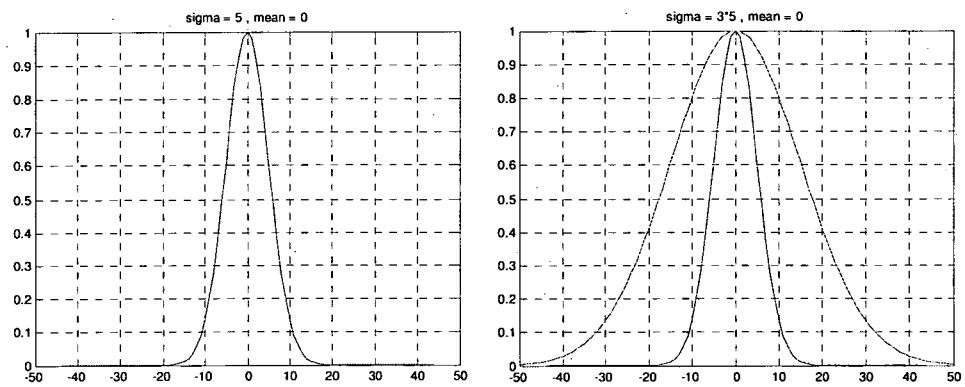


Figure 5

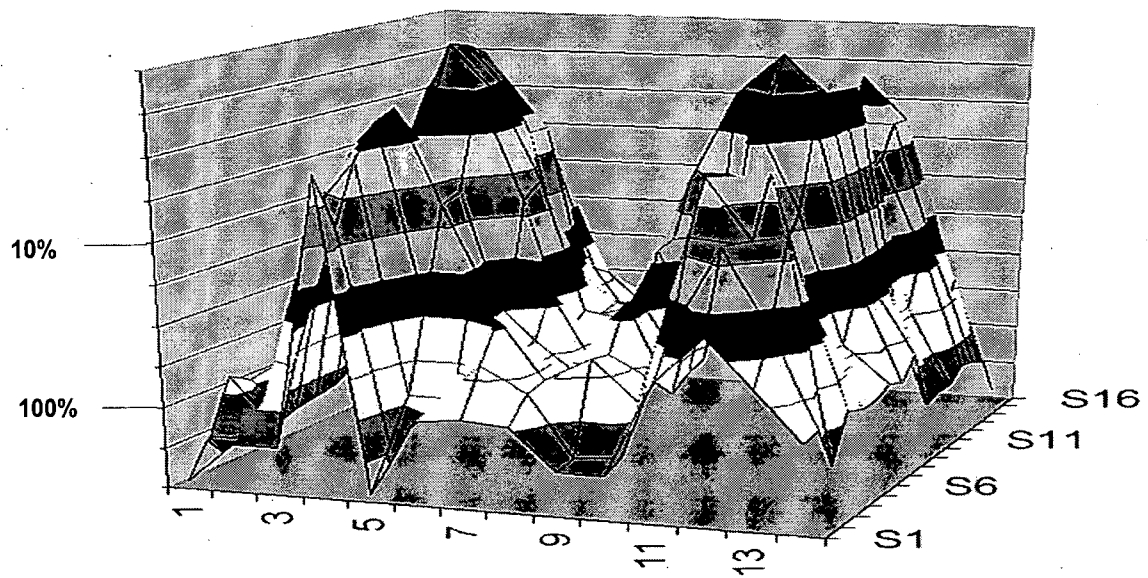


Figure 6

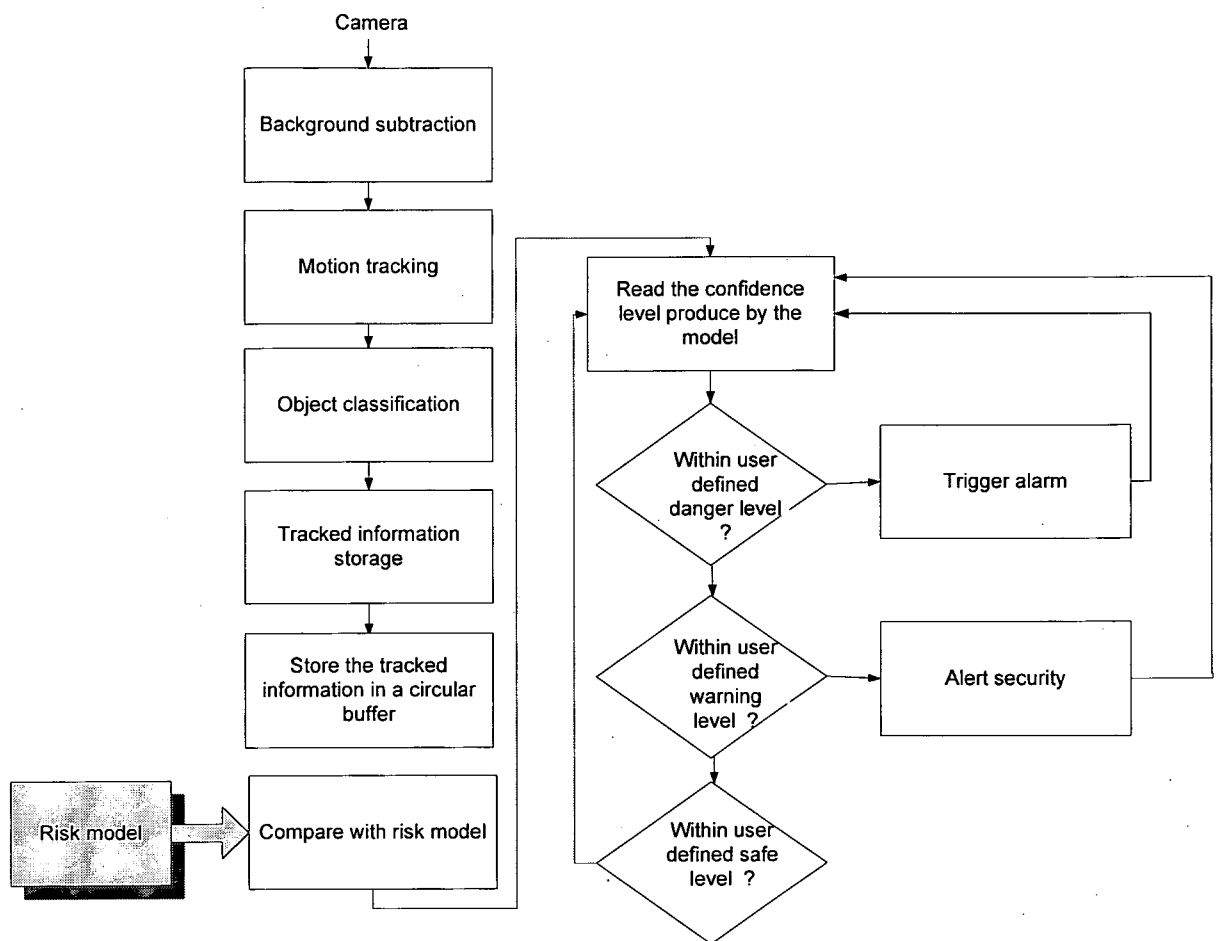


Figure 7

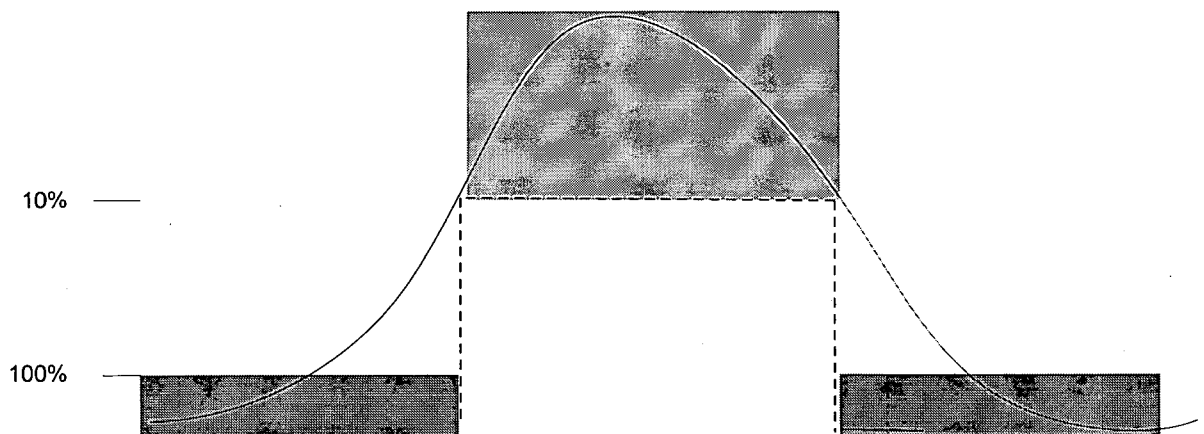


Figure 8

INTERNATIONAL SEARCH REPORT

International application No.

PCT/MY2010/000092

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

G06F 17/30 (2006.01)

G06Q 99/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
 WPI & EPODOC: Keywords- risk, surveillance, map, graph, path, Gaussian, deviation and like words.
 Google Patents and Patent Lens databases: Similar keywords as above.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2007/0016542 A1 (ROSAUER et al.) 18 January 2007 See abstract and figure 1	
A	US 7,003,136 B1 (HARVILLE) 21 February 2006 See whole document	
A	US 7,127,083 B2 (HAN et al.) 24 October 2006 See whole document	



Further documents are listed in the continuation of Box C



See patent family annex

* "A" Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 11 August 2010	Date of mailing of the international search report 20 AUG 2010
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustalia.gov.au Facsimile No: +61 2 6283 7999	Authorized officer DEBASISH DASGUPTA AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No: +61 2 6283 2587

INTERNATIONAL SEARCH REPORT

International application No.

PCT/MY2010/000092

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Claims 1-5 are directed to a method of risk model development. It is considered that extracting a line profile from an occupancy map, detecting peaks in the line profile, modelling the peak inline with Gaussian distributing equation, populating an occupancy graph by rows and columns, calculating a path deviation risk table and generating a path deviation risk map from the risk table comprises *a first special technical feature*.

Claim 6-8 are directed to a method of determining safe zones from a risk model. It is considered that detecting tracking data from input devices, comparing data with a risk model in a provided database and verifying tracked data is within a predefined safety zone comprises *a second special technical feature*.

Since the above mentioned groups of claims do not share any of the technical features identified, a "technical relationship" between the inventions, as defined in PCT Rule 13.2 does not exist. Accordingly the international application does not relate to one invention or to a single inventive concept.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: **1-5**

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/MY2010/000092

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
US	2007016542	WO	2007005975		
US	7003136	NONE			
US	7127083	US	2005104727	US	7088846
		US	2005104962	US	7136507
		US	7148912	US	7499571
		US	2005104960	US	2005105764
				US	2005105765
				US	2005104961
				US	2005104959
				WO	2005050581
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.					
END OF ANNEX					