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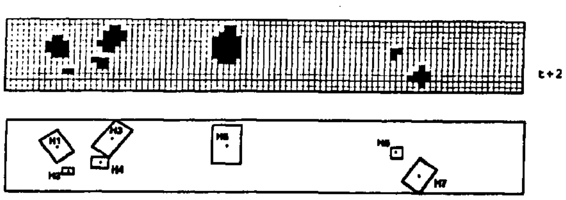
(54) **People counting system by pressure images**

(57) This people counting system is composed of one or more sensor surfaces each one formed by independent pressure sensible cells in a bi-dimensional matrix arrangement, and frequently installed on a small dimension stair step, capable of providing a pressure image every few milliseconds; and of one or more pressure image analysing systems capable of collecting the images generated through the sensor surfaces and, by means of image processing methods, detect the number of footprints left on every surface during each sampling period, link the footprints detected on consecutive events, determine (by their past history) their moving direction, group the possible footprints of each person and count them on the correct direction when they leave the surface.



	XN	XM	YN	YM	C	CG	N
H1	7	10	3	6	(8.5, 4.5)	(8.6, 4.6)	13
H2	10	11	9	9	(10.5, 9)	(10.5, 9)	2
H3	16	20	1	5	(18, 3)	(18.1, 3)	16
H4	15	17	7	8	(16, 7.5)	(16.2, 7.4)	5
H5	36	40	1	7	(38, 4)	(38.03, 4.25)	28
H6	67	68	5	6	(67.5, 5.5)	(67.3, 5.33)	3
H7	70	73	8	11	(71.5, 9.5)	(71.78, 9.55)	9

Fig. 4

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Description

[0001] This invention consists of the application of the newest technologies in the field of pressure sensors and digital image processing to the measurement of the flow of people coming in and out of a certain area. The operation principle is based on acquiring and analysing pressure images generated by people's footsteps when leaving or going into a public transport vehicle (bus, subway, train, etc.), frequently through a small dimension stair step. And it can also be applied to counting people entering or leaving a certain building, office, shop, etc...

[0002] Combining the two above mentioned technologies, a strong, reliable, low cost, versatile and installable on-board in a mass transportation vehicle, people counting system is proposed.

[0003] By means of an adequate sensor, surface bi-dimensional images containing information about the pressure applied on the surface when people walk on it are obtained. These images are real-time generated and with a relatively high resolution, for pressure elements.

[0004] Then, the acquired matrixes are analysed using digital image processing algorithms, identifying in this way people's footprints, as well as their direction, allowing a reliable control, regardless the amount of people, footstep speed or any other factor. The obtained data, together with information about the location, date and time of the measurements are saved into a historic database in the same processor.

[0005] In order to analyse the generated data, they can be recovered using an operational sub-system designed for this purpose, which also allows to work on the statistic evaluation tasks, graphic presentation and to export the data to other remote analysing systems.

State of the art

[0006] The technical development of people or passenger counting systems has been stopped world-wide for several years, because of the impossibility of obtaining cost-effective high technology solutions, until very recent times. In this sense, we can count the US Patents US-4.00.400, US-4.122.331, US-4.175.446, US-4.303.851, WO-97/22089 and WO-97/23376 in which counting systems are basically based on detecting, in a more or less complicated way, the footsteps on the bus stairs and thereafter, using simple algorithms, count the number of passengers in the bus. Although, in some case, inventions are more complicated, as the last one mentioned above, which is similar in its external aspects and applications to the one here described.

[0007] Being the number of used footstep sensors very low (one by step or two in several steps in the most complex systems), the error rate grows very rapidly, specially in crowded situations, which are the usual ones. Moreover, the existence of steps is often necessary for the use of these inventions.

[0008] Other recent solutions are closer to this proposal, even using bi-dimensional arrays of pressure sensitive sensors and processing of footprints to compute the number of persons walking on the access surface and to determine their moving direction. One of these is, for instance, the publication in WO 98/40719, although it claims for a method instead of an entire system, and it does not solve problems such as static or incomplete footprints. That makes this method hardly applicable for environments as entrances of mass transportation systems.

[0009] On the other hand, there is a number of patents that claim for constructing methods to manufacture pressure sensitive surfaces but that subject is omitted in this patent.

[0010] Other technologies use infrared sensors installed on the ceiling of the vehicle, using multiple sensors for each door. Precision on the most simple systems can't overpass the 75% for one-direction traffic. The most complex and expensive systems can guarantee an accuracy of up to 90 % even in bi-directional traffic conditions.

[0011] The system here proposed allows an accuracy rated between 96% and 99%, being a cost-effective and easy to use and to install solution.

General description of the invention

[0012] The purpose of this invention is to automatically count the number of persons that pass through an access zone of a certain place or building and to know their direction of movement. The width of the access zone can have any dimension and people can walk through it completely free, one by one or in groups, moving continuously or stopping on it, in one or both directions and with no restrictions on their absolute position on the passing area.

[0013] Supposing any way of going in or out of a specific building, public transport vehicle or any other closed place which has walls and access zones (for our purpose it does not matter that people come in and out in an ordered way or not), it is a must that people step on the floor (or on any existing steps) to move in or out of this certain place. To do so they will have to step on a certain limited surface of the access zone, or on a step if stairs exist. We will initially suppose that both the probability of jumping over these zones and the probability of advancing with successive steps across them are very low (due to their design and dimensions) and that these events are not very relevant.

[0014] The People Counting System by Pressure Images is based on the acquisition of digital pressure images from an existing surface on which people to be counted walk, stepping on it. A pressure image is a bi-dimensional pressure value matrix obtained by scanning the elements that form the sensor surface in a certain moment. The techniques used to measure the pressure exerted on each sensor and the means to scan them are diverse and do not form part of the subject of this patent.

[0015] Using matrix sensors with an appropriate spatial resolution, the system discriminates between the footprints of several persons stepping simultaneously on the sensor surface. Moreover, if several pressure images per second are provided, the system reliably identifies the direction of movement for each footstep when it leaves the surface and, consequently, the advance direction of the person it belongs to. This is achieved whether the footprints keep completely inside the sensitive surface or whether they imprint only partially on it, as it occurs in the event of a small depth sized step of a train, bus or access stair for a closed place.

[0016] The People Counting System consists of one or more sensor surfaces which are formed by a bidimensional matrix of independent pressure sensible cells, capable of providing a pressure image every few milliseconds; and of one or more pressure image analysing systems capable of collecting the images provided by the sensor surfaces, and, using image processing techniques, detect the partial or complete foot-marks existing on every surface in each scanning period, connect the same foot-marks present on successive scanning periods to identify the footsteps of one person, determine (by their past history) the direction of movement of all of them, link the footprints of each person because the possibility exists that it remains for some time over the sensitive surface, and count people in the right direction when leaving the surface.

[0017] In the context of this description, we will be using the term "foot-mark" to describe each one of the stepped areas imprinted on the sensitive surface. A footstep of one person may generate, in one scanning instant, several "foot-marks" (areas of active adjacent pixels) that are shown on the pressure image, depending on the number of contacting points on the surface (toe, heel, shoe-side...), on the kind of footwear used and on the cells sensitivity. Specifically the number of foot-marks produced by a footstep in the pressure image corresponding to a sampling instant may be higher than two.

[0018] The term "footstep" describes each of the supporting contacts of one person's foot on the sensitive surface, and it has a temporal dimension: a person's footstep is the same one although it may be detected in many successive images, even if the number of foot-marks it leaves on the sensitive surface or its shape or its apparent position in the pressure image changes. Moreover, some of the relevant attributes of the footsteps are their course and advancing direction, magnitudes related to their temporal evolution.

[0019] The proposed people counting system may be installed in a permanent location or may be placed on-board on a public transport vehicle, since it does not require big size sensitive surfaces and it can be easily adjusted to their access dimensions.

[0020] This system can also accept other auxiliary information sources, to facilitate both the counting mechanism and the following information treatment. Such sources are, for instance, a real time clock (to assign temporary attributes to the counts), opening and closing signals from the doors (to avoid erroneous counting when doors are closed or to detect when the equipped vehicle is on a stop), odometer or tachometer signals (to assign spatial or way attributes to the counts, and to identify when the vehicle is moving), data from a GPS receiver (to precisely detect the position of moving systems), signals for pre-determining people's access direction, zero counter signal, etc.

[0021] The obtained data of counted people, and all the other relevant information for each application, are immediately provided and can alternatively be stored in the system, to be used later by an external exploitation system. To meet this requirement, data storing and communication devices can be added to the People Counting System, as well as suitable information access mechanisms, to facilitate local or remote transmission of data.

[0022] The main advantages of this system compared to those existing in the same field are:

- its accuracy, thanks to its capability of detecting different footprints belonging to different people stepping at the same time on the transit sensor surface and therefore minimizing the "occlusions" of other technologies (infrared barriers, video cameras, only longitudinal or transversal sensors);
- it is an intrinsically bi-directional counting method, as the analysis of a high number of images per second allows to recognise the form and position of each footstep along time;
- it goes unnoticed to the general public, reducing the risk of vandalism and the possibility that detection affects the obtained measures;
- it does not block people passing, easing the access and evacuation of the places whose capacity wants to be measured;
- the small size of the sensitive surface needed, that decreases their own cost, reduces the processing capacity requirements for the corresponding pressure images and minimises the counting errors due to the identification of successive strides of the same person, most of all in crowded areas;
- the proper handling of footsteps belonging to people who stay a prolonged time over the surface, because of queues or obstacles obstructing the continuous movement of persons.

<u>Brief explanation of the drawings.</u>

[0023] In its most basic version, the People Counting System using Pressure Images is formed by a sensor surface [1] set on an access zone of the control region, plus a pressure image processor [2]; both interconnected by any medium capable of transmitting electric signals [3]; see figure 1.

[0024] In the processor, images transmitted by the sensor surface are captured and, for each one, the following processing stages are carried out, as seen in figure 2: once the pressure images IP have been acquired, the processor will do a binary conversion (4) of them; using the binary images IB, a classification of the stepped zones (5) is made, and, based on this, an LHI image foot-mark list is built. Thereinafter, an assignment of foot-marks to footsteps (6) is made, using for this purpose the present foot-mark list (LHI) and the previous footstep list, LI; therefore an updated footstep list LIA is obtained. After this procedure and based on a collection of rules (LR) specifically designed to this goal, footsteps are grouped in persons (7), using the present footstep list and the previous person list, obtained in the preceding image; thus, the updated people list, LEA, for the present image is calculated. Finally, adding several convenient additional signals (SA), the system counts people (8), resulting in a certain number of persons moving in each direction, NPCS.

[0025] As a result of the pressure images binary conversion stage, every pressure image captured is converted into a two levels image, each pixel having the value STEPPED or FREE. A graphic representation of a sequence of such images can be seen in figure 3. In it, you can notice the footprints of three different persons printed simultaneously on the sensor surface and its evolution along time. Instants in which people are to be counted as well as their moving direction have been marked using a circle and an arrow.

[0026] Figure 4 represents the entering image in (t+2) instant, together with the **foot-mark list** calculated for that image and a table including the appropriate parameters in the same moment (see the explanation of those parameters in the list included at the end of the description).

[0027] In figure 5 the **footstep list** originated after processing the images between instant (t) and (t+4) is shown, as well as a graphic representation of the footsteps over the last entering image in moment (t+4).

[0028] Figure 6 shows the list of people generated after processing images in the same period, this being from (t) to (t+4).

Detailed description and preferred embodiments

[0029] **The sensor surface** is formed by a collection of independent pressure sensors, set as an N row x M column bi-dimensional matrix. To begin, we will suppose that we have a rectangular surface, although the sensor group can be adapted to other polygonal forms by only removing the cells out of the desired perimeter. In any case, the image provided by the sensors will be an N x M pixel matrix having zero pressure values in the places corresponding to the cells out of the perimeter.

[0030] The sensor surface will have its dimensions adapted to the controlled transit zone, being width enough to cover all the stepping zone and with a longitudinal dimension large enough to avoid people skipping it when walking normally, but not as much as to permit several treads of a single person (typically around 40 to 60 cm) although it may step on it with both feet simultaneously. If installed on a stair step, the sensor surface should adapt its dimensions. It is not required for the footprints to be completely inscribed inside the sensitive surface. The size of the surface must be enough to show complete at least the toe or the heel of a footprint, in order to detect in successive images its direction of movement, based on the size and position of the impressed foot-marks. If the sampling rate (in images per second) and the resolution (in pixels per meter) are high enough, the stair step where the system is applied may be as few as 10 or 15 cm. deep longitudinally (in the main direction of people transit).

[0031] Cell sizes and the distance between them should be as to permit the reproduction of a 5x10cm footprint (as the children's) in not less than 2 x 3 pixels, in order to be able to determine its centre and moving direction. This gives us a maximum sensor distance of about 2.5 cm, being better as it decreases.

[0032] The sensor surface sensitiveness allows the distinction as different states, of pressure variations as small as a child's weight divided on its two stepping feet; this equals typically a minimum pressure of about 0.2 kg/cm^2 (20 kg standing on two 5 x 10 cm feet). Moreover, the surface is able to receive with no permanent deformation the maximum pressures produced when the whole weight of a person is applied on a slim heel.

[0033] The sensor response speediness allows the sampling of all the surface to take at least 3 images of footsteps lasting a minimum 100 ms on the surface, what means sending the information at least at a 30 image per second rate (33 ms/image). Furthermore, it responds very quickly to pressure variations, passing from a maximum pressure state to resting position and vice-versa typically in less than 20 ins.

[0034] The sensor surface is waterproof and resistant to external aggressions as water, soft acids, detergents or soft bases as well as to temperatures in the range of -10° C to +50 ° C. It is also resistant to the erosion and to a certain degree of torsion, flexion, etc. Its external appearance is such as not to attract the attention towards it in any place it is installed (bus, doorway...), in order to avoid people to reject stepping on it and any casual vandalism acts; the existing electronics and the interconnection with the rest of the system remains hidden from people view.

[0035] Every pressure image obtained on the sensor surface is real time sent to the processor over different interconnecting devices, what is achieved using an open interconnection interface. Thus, pressure values can be transmitted serialised (one data value after another) or in parallel (several data values at a time), in the form of analog (for instance a voltage value which is proportional to each sensor pressure), digital (by means of a number, representing the pressure value of each cell) or binary signals (telling if sensor is activated or not), using a physical medium (metallic or optic fibre) or aerial (radio signals, infrared signals...) or by means of any other state of the art existing electrical signal transmission method. It is noted that the resolution used by the invention, as well as the number of images needed per second, force to use a transmission medium with high capacity and good noise and error protection values.

[0036] The processor that analyses the acquired pressure images may be a general purpose processor or a specific one for this system. Anyway it must fulfil some requirements to be placed on-board on a public transport vehicle (being roughed , low-power consuming, with no moving parts, vibration resistant...), to allow receiving pressure images from several sensitive surfaces, to provide optional permanent data storage and communication capabilities and to accept the connection of those auxiliary devices previously mentioned (real time clock, opening doors signals, odometer or tachometer, GPS location device, one way signal and zero setting signals...).

[0037] As the incoming images transmitted by the sensor surface are being captured, the following stages are carried out in the processor for every sampling period:

- Pressure image binary conversion (4):

[0038] Regardless of the pressure image transmission means, the information of each sensible element is transformed into binary format, to allow its further treatment. In the case of analog or digital images, this would be done by comparing the pressure level or value with a reference level which can be a single one for the whole surface or a particular one for each cell depending on its previous state. The elements surpassing the reference level will be active (stepped) and those which don't overpass it will be in resting state.

[0039] As a result of this first stage, every pressure image captured is transformed into a two-level image, having now each pixel an STEPPED/NOT-STEPPED value. Figure 3 shows a graphic presentation of a sequence of pressure images. We can appreciate footprints belonging to three different persons at the same time. The moments in which people are to be counted, as well as their moving direction are marked by a circle and an arrow.

- Stepped zone grouping (5):

[0040] For each existing image, the system has to identify the boundary zones of the stepped elements. Each of those boundary zones corresponds to the "footmark" left by a part of a certain footstep. It must not be a full footprint and there may be a variable number of them (1, 2 or more).

[0041] Detection of foot-marks is done using just the present binary image, not taking into account the state of the pixels in previous images. Thus, for every sampling period, all the foot-marks on the surface are collected, leaving the calculation of the temporal and motion attributes to the subsequent processing stages. This way the identification of a footstep may be done properly even if it remains a long time over the surface.

[0042] Amongst the different image processing techniques, several methods can be used in order to identity and characterise those foot-marks depending on the connectivity of the active pixels, as well as different noise filtering algorithms (to remove falsely detected pixels) which could have been generated in the previous stage.

[0043] These techniques allow the system to identify, for each boundary zone or foot-mark, a set of spatial attributes, such as the coordinates of the rectangle that inscribes it (XN, YN), (XM,YM), its different centres (geometrical centre (C), gravity centre (G), or other), the number of active points which form it (N), a boundary polygon, etc.

[0044] As a result of this stage, a list of foot-marks or stepped zones is created, each one together with its own characteristics.

[0045] Figure 4 presents the entering image in moment (t+2), together with the footprint list calculated for the image in that moment.

- Foot-mark to footstep linkage (6):

[0046] Each footstep, generated by the stepping of some person's foot on the sensor surface, may generate several foot-marks on it. Depending on the number of stepping points (toe, heel, shoe-side...) and on the cells sensitivity, one step may result on a group of active zones in the image, close each to other although not adjacent. All the different foot-marks belonging to just one footstep will be set in an image area not larger than a foot maximum dimensions, and set in a longitudinal way along the foot principal's edge.

[0047] To decide on every image, which foot-marks correspond to each footstep, the system uses the footstep's historic information, which keeps current position data (in a similar way to the foot-marks), previous position data (for instance the last boundary rectangle, its centres' list (CA, CGA), its moving direction, its maximum detected dimensions ((XNN,YNN), (XMM, YMM)) and time data (such as the number of images in which it has been present (NI), its appearance instant (TP), the last image in which it has been detected, etc.).

[0048] This way there is no need of storing and reprocessing neither previous images nor the foot-mark lists from all the preceding instants. Processing is always done based on information elaborated in previous images plus that obtained from the present one, not depending on retroactive computation.

[0049] A certain foot-mark will belong to a certain existing footstep if its centres fall inside the predicted rectangle footstep and its final size, when linking them together, won't overpass the maximum allowed dimensions of a foot. When assigning a foot-mark to a certain footstep, the current and historic footstep's information is updated based on the spatial characteristics of the analysed foot-mark. For instance, the footstep's boundary rectangle gets actualised in the present image, its centres get recalculated, the number of detection or the number of images in which it has appeared, its last appearance time, its maximum dimensions, etc. Once the analysis of all the image's foot-marks has finished, these data are added to the footstep's information to predict its next possible position and its present moving direction is calculated. To obtain it, the trend of its most recent gravity centre position samples can be used, for example.

[0050] If no footstep to which associate the current print is found, a new footstep will be created and the foot-mark will be linked to it, initialising its data according to the current footprint's characteristics.

[0051] As an exit, this stage will provide the list of detected footsteps with new added data using the foot-marks linked to each one on the current image. This list does not disappear with each image, but is stored, keeping the historic information of the footsteps that still are on the sensor surface.

[0052] When any footstep in the list has no longer a foot-mark linked to it, the system validates its exit direction. This will be the last moving direction computed when the footstep still had assigned foot-marks. This way, the exit direction can be properly determined for footsteps that have been toggling between the toe an the heel, or from one shoe-side to the other, or whose parts have been detected in the order toe-heel-toe (as it is frequently when going down from a stair step). It has been experimentally probed that, whatever the sequence of contact parts of a foot has been, while it is staying over the sensitive surface, practically the whole people raise their feet from heel to toe when they leave the surface; and that it is much more reliable to use the apparent advancing direction of one footprint when it is leaving the pressure images than when it newly appears on the surface to determine its moving direction.

[0053] If the lack of associated foot-marks condition is maintained for a footstep during several images (the foot-marks may be missing in one image, but the footstep may reappear in the following ones), its record is removed from the updated footstep list, definitively.

[0054] Figure 5 shows the footstep list created after processing the images, from instant (t) and (t+4), and a graphic drawing of the footsteps on the last entering image.

- Footsteps to persons assignment (7):

[0055] The goal of this stage is to determine which footsteps correspond to the same person standing on both feet on the sensor surface and which ones belong to different people.

[0056] The system uses a variety of experimental rules and a set of values to apply them.

[0057] These data are adjusted after experimental analysis in "standard applications" (a bus or train entrance stair step, the entrance of a mall or of a certain store, etc.) where those values are obtained using statistical methods to produce the best precision results in the final count of people.

[0058] Some of the rules to group footsteps into persons are the following:

- Footsteps which centres are not longer from a certain distance may be grouped, being this distance the normal distance between a person's feet, and which must be adjusted statistically in previous tests.
- It is not allowed to add more than two footsteps to one person.
- A footstep detected very few times is not allowed to group with any other one (because there is no reliable information on it). The minimum number of detections to link one footstep to other is experimentally determined for each "standard installation".
- Two footsteps with different moving direction (in between the possible established) or which moving vectors form an angle greater than a predetermined value can not be grouped together.
- Two footsteps having another one in between them, not compatible with any of them, cannot be grouped together.
- If the time of the first detection of two footsteps appearing on the sensor surface is lower than a predetermined experimental value, the steps can not be grouped together (nobody enters the surface with both feet at the same time).
- A footstep that has just disappeared (in a previous moment) can only be grouped with another one in the same position, and will belong to the same person's foot. If a new footstep appears moved from its previous position it must belong to a different person.

[0059] Applying each of these rules and some more which can be fixed is subject to the tests carried out in the "standard installations".

[0060] As an exit of this stage a list of persons detected on the surface is provided, containing data updated using the footsteps linked to each one in the current image. This list does not disappear with each image but is stored, keeping the historic information of people remaining on the sensor surface.

[0061] People processing is always done based on the person list information elaborated in previous images plus the footstep list calculated from the current one. This way there is no need of storing and re-processing neither previous images nor the footstep lists from all the preceding instants.

[0062] Figure 6 shows a list of people created after processing the images in the same previous interval of time, this is between (t) and (t+4).

- People counting (8):

[0063] If any person in the list has no more linked footsteps in several consecutive images, the system considers that it has left the sensor surface. It is then counted and deleted from the persons list. The direction of movement given to this person will be the exit direction of its last assigned footstep, which is maintained as a person attribute even when the footsteps disappear.

[0064] If the system has additional information sources, such as door opening signals, vehicle motion detection signals (odometer, tachometer), zero setting or one direction signals, etc. they can be used in this stage to avoid people miscounting in the sensor surface, for instance when doors are closed, or when the vehicle is moving (on board systems) or to predetermine the people counting direction.

[0065] In all these processing stages, the absolute position of each footstep on the sensor surface is not taken into account, as the clue facts are the spatial and time relations in between the different detected footsteps, and it is contemplated the fact that one or more persons remain for a significantly long time on the sensitive surface. Moreover, they are applicable even if the footstep list comes from one singe platform or from a bigger image formed by several platforms, controlled by one or more processors. This is a flexible method, which adapts to any position of people on the surface not limiting its access zones or its possible movements. Using this system, a typical accuracy of 96.5% in 1,000 people samples can be obtained. The accuracy increases up to 99% in bigger samples (of around 75,000 people).

[0066] The processor increases the people count until some predetermined event takes place. Such an event may be the generated by the end of the programmed time for periodic storing, the door locking, the movement of the vehicle where the system is installed on, or by pressing the count reset button, etc. Then the count obtained in each relevant direction is stored in a file, recording the time when the count has been stored and any other significant information (travelled distance, GPS coordinates obtained via satellite, or the status of any input signals).

[0067] For on-board systems, position information is decisive to analyse the people count measures obtained; in fixed systems, the relevant data may be the time of the measured period. In both kind of systems the automated system proposed is able to historically store the computed measures and ease its further consulting (communication devices, protocols, etc.). Starting from the data provided by the system, subsequent information can be produced and very useful statistics for any business can be obtained.

[0068] **Other system implementations** allow the connection of several sensor surfaces, each corresponding to one of the existing entrances to a certain place, to just one processor, having different inputs to this effect. In this case, the image analysing and people count procedure is repeated for each image of each surface independently. The global bi-directional people scores may be collected in order to obtain the total number of visits to the controlled place.

[0069] In other applications, it is possible that the sensor surface technology will not cover the whole width of the passing area. In this case, several surfaces will be set, one next to the other, until the desired dimensions are obtained. Each sensor surface will provide its own image, as in the general case, but the system will have the particularity that all the surfaces will be synchronised in time by a common processor. The processor will collect the images of all the sensor surfaces and, before starting the analysis, it will attach all of them in memory to form a single image of the necessary dimensions. The remaining processing stages will be done as in the general case.

[0070] On the other hand, the dimensions of the controlled surface may surpass in connection number, memory capacity, or processing capacity the performance of a single pressure image processor. If this comes to happen, a pyramidal structure formed by several processors linked one to the others is proposed (communicating serially, in parallel, sharing memory...). Those processors in the base of the pyramid would acquire the images and treat them until obtaining the footstep lists on the surface, providing its sizes, positions and their remaining characteristics, and sending them to the upper processors. These would collect the information and will do the tracking of footsteps and persons to reach the final counting process and the direction of movement assignment.

LIST OF PARAMETERS USED IN FIGURES 4, 5 AND 6

[0071]

Figure 4:

- H1, H2, H3, H4, H5, H6, and H7 represent the different foot-marks left by three persons footsteps on the sensor surface, in moment (t+2).
- XM, XN, YM and YN are the maximum and minimum X and Y coordinates of each footmark, according to a theoretical coordinate system on the surface.
- C represents geometrical centre of a foot-mark.

- CG is the foot-mark gravity centre (ΣXi/N, ΣYi/N)
- N is the number of active cells.

Figure 5:

- P1, P2, P3 and P4 are the generated footsteps after processing images from instant (t) to (t+4).
- CA represents the previous geometrical centres of the footstep.
- CGA represent the previous gravity centres of the footstep.
- XNN, XMM, YNN, YMM are the minimum and maximum values of the XN, XM, YN and YM.
- NI is the number of images in which a certain footstep has been detected.
- TP is the moment in which the footstep firstly appeared.

Figure 6:

- PS1, PS2 and PS3 represent people detected after processing the footstep in the images.
- CONT indicates if the person has been counted or not.
- SAP indicated the current moving direction associated to the person (it will be definitive when the footstep exits the surface): AR= up and AB= down.

Claims

1. People counting system using pressure images comprising one or more sensor surfaces and one or more processors, linked to each other by any signal transmission medium, wherein each one of the sensor surfaces is formed by a bi-dimensional array of independent cells sensible to the pressure; from such surfaces, in consecutive sampling times, digital pressure images are obtained of the whole or partial footprints left by people walking on it, these images being analysed by image processing techniques to count the people passing over the surface, not being a requirement for the mentioned surface to completely contain an entire footprint of a person.

2. People counting system using pressure images, according to claim 1, wherein one or more sensor surfaces cover the accesses to a particular place and their images are analysed by one or more processors, counting in real time the people passing over the surfaces and assigning their moving direction when they leave them, with no practical restriction regarding the number of people on the surfaces or regarding their absolute position on them, not even on the possibility that people remain a finite time on the surfaces.

3. People counting system using pressure images, according to any of the previous claims, wherein the interface between the sensor surfaces and the image processor, allows the transmission of the pressure values serially or in parallel, in the form of analog, digital or binary signals, over a physical or aerial medium or any other electric signal transmitting method.

4. People counting system using pressure images, according to any of the previous claims, wherein the processor, once collected and binary convened the sensor surface images, detects the existing foot-marks in each sampling period, relates the different foot-marks each to others to identify partial or complete footsteps, calculates the current moving direction of the footsteps (based on the detected foot-marks for the present image and on information elaborated in previous sampling instants), links the footsteps of each person and counts it in the appropriate direction when it leaves the surface.

5. People counting system using pressure images, according to any of the previous claims, wherein the response time of the sensor allows taking at least 3 samples of footsteps remaining on the surface at least 100 ms, which equals sending the information at least 30 images per second.

6. People counting system using pressure images, according to any of the previous claims, wherein for each individual acquired image, disregarding any other ones, the stepped zones are grouped and a list containing spatial information about the foot-marks is created.

7. People counting system using pressure images, according to any of the previous claims, wherein the foot-marks are assigned to footsteps, creating a list of the footsteps detected on the surface, and to decide which marks belong to a footstep, with no limit concerning their number, historic previous information about the footsteps and spatial data of the foot-marks in the current image are used.

8. People counting system using pressure images, according to any of the previous claims, wherein the footsteps of the list which have no assigned foot-marks get their exit direction validated, previously calculated using their most recent positioning data as it leaves contact with the sensitive surface and, when this condition remains true for several images, are then deleted from the footstep list.

9. People counting system using pressure images, according to any of the previous claims, wherein the

footsteps are grouped, forming then a person list staying on the surface for each sampling period, using a collection of particular rules.

10. People counting system using pressure images, according to any of the previous claims, wherein for any of the persons in the list which have no assigned footsteps during several consecutive images, it is supposed to have left the sensor surface, it is then counted and deleted from the people list. The exit direction attributed to it is the exit direction of the last of its associated footsteps.

11. People counting system using pressure images, according to any of the previous claims, wherein additional inputs are provided, such as door opening signals, motion indication signals for systems installed on-board vehicles, reset counter signals or one way signals, which are used to determine the passing direction of the counted people and/or to avoid miscounting, although the system operation is not restricted by their condition.

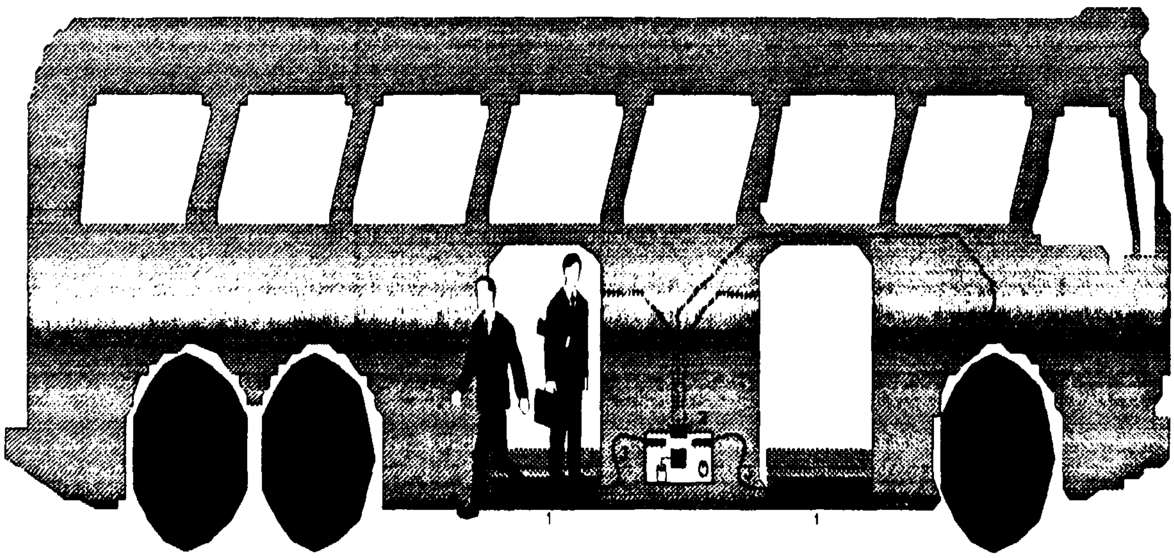


Fig. 1

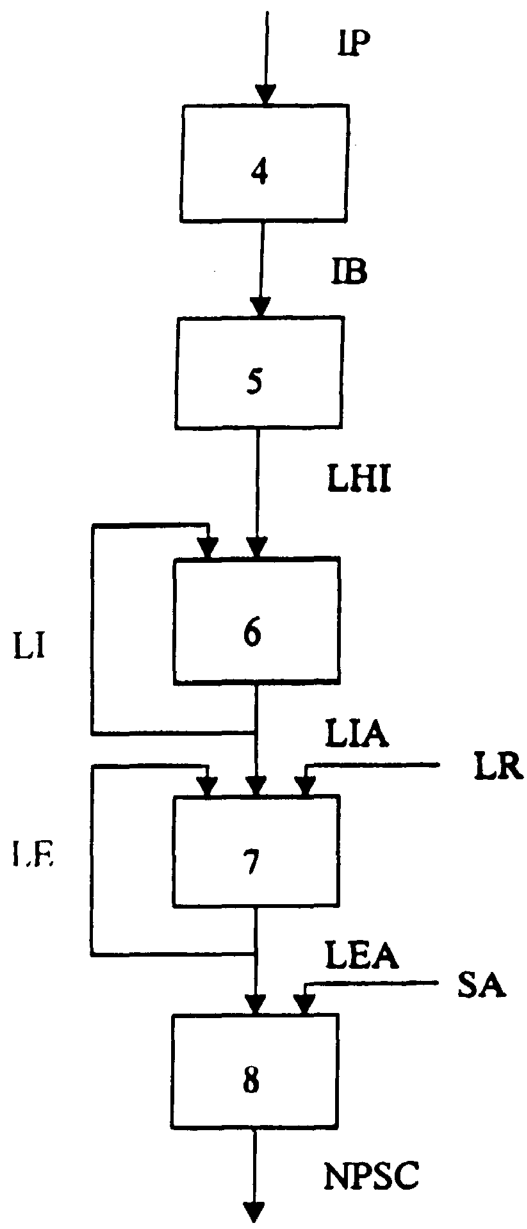


Fig. 2

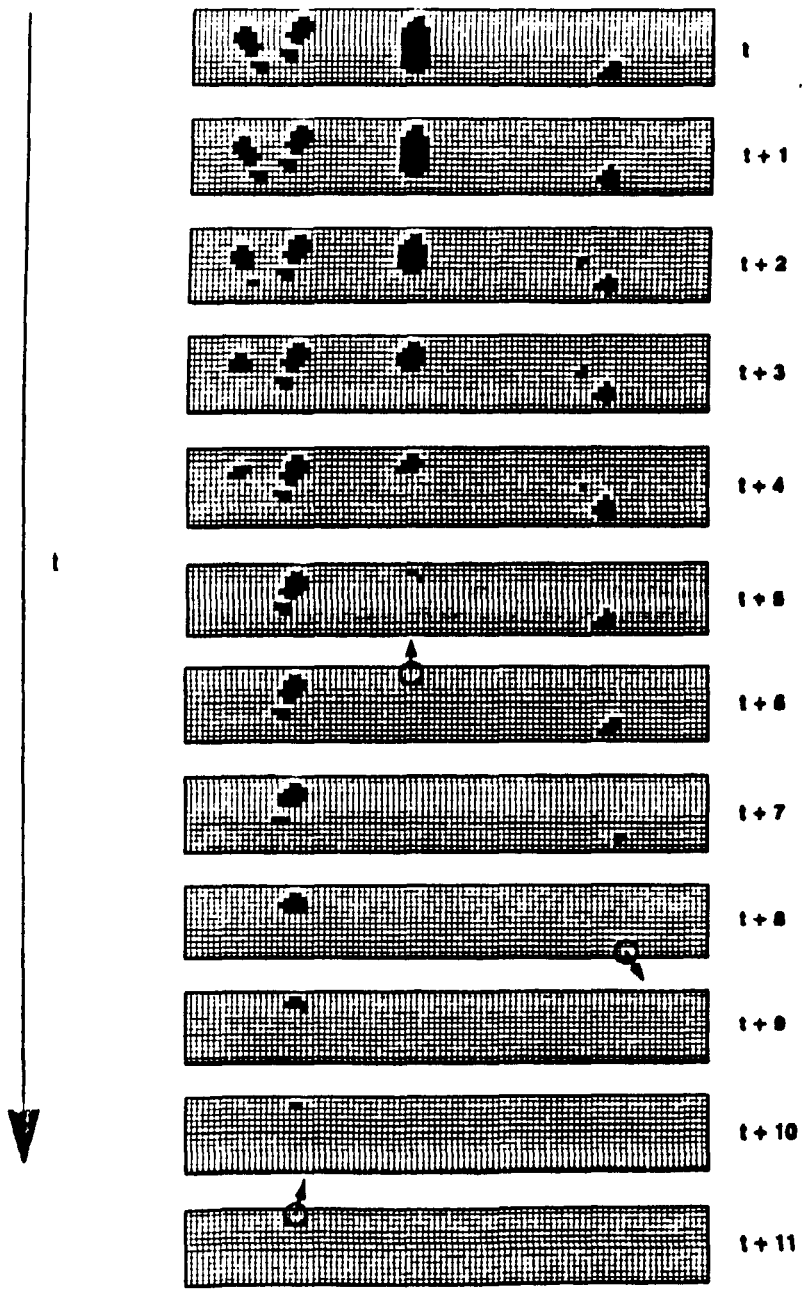
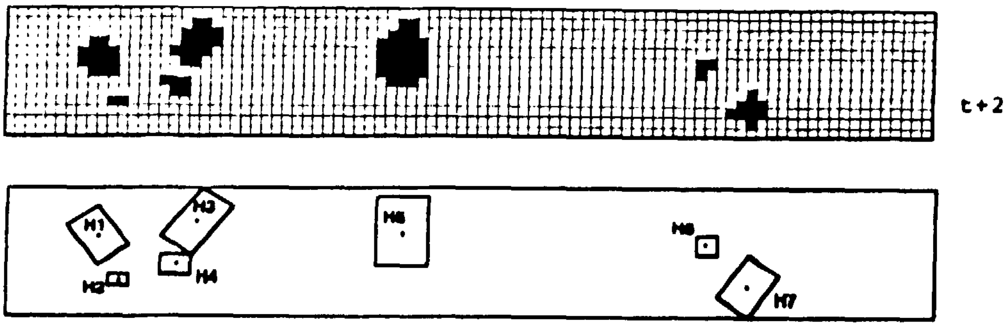
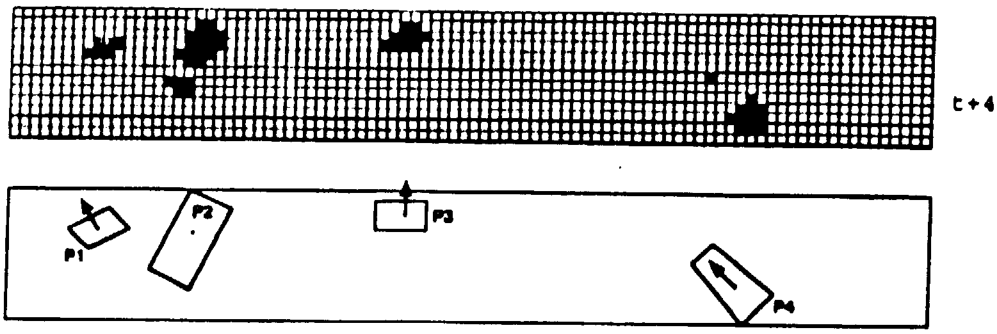


Fig. 3



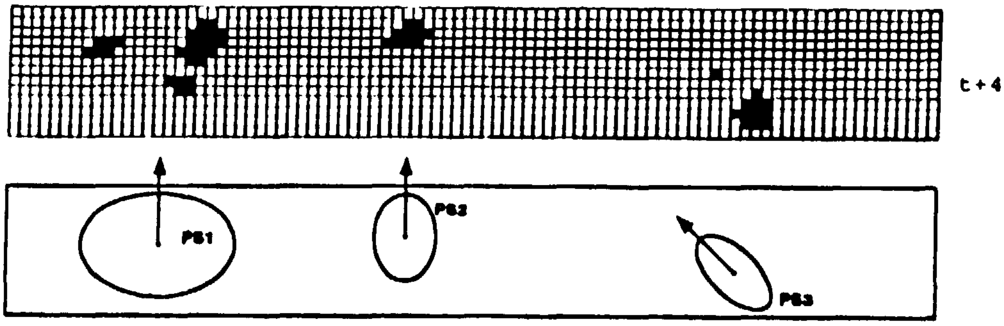
	XN	XM	YN	YM	C	CG	N
H1	7	10	3	6	(8.5, 4.5)	(8.6, 4.6)	13
H2	10	11	9	9	(10.5, 9)	(10.5, 9)	2
H3	16	20	1	5	(18, 3)	(18.1, 3)	16
H4	15	17	7	8	(16, 7.5)	(16 2, 7.4)	5
H5	36	40	1	7	(38, 4)	(38.03, 4.25)	28
H6	67	68	5	6	(67.5, 5.5)	(67.3, 5.33)	3
H7	70	73	8	11	(71.5, 9.5)	(71.78, 9.55)	9

Fig. 4



	P1	P2	P3	P4
XN	7	15	36	68
XM	10	20	40	73
YN	3	1	1	6
YM	4	8	3	11
C	(8.5, 3.5)	(17.5, 4.5)	(38.0, 2.0)	(70.5, 8.5)
CG	(8.5, 3.5)	(17.67, 4.05)	(38.10, 2.20)	(71.50, 9.50)
H	H1	H2, H3	H4	H5, H6
CA	(9.5, 6.5), (9.5, 6.5), (9.0, 6.0), (8.5, 4.0)	(17.5, 4.5), (17.5, 4.5), (17.5, 4.5), (17.5, 4.5)	(38.0, 5.5), (38.0, 5.0), (38.0, 4.0), (38.0, 3.0)	(71.5, 10), (71.5, 9.5), (70.0, 8.0), (70.0, 8.0)
CGA	(9.43, 6.05), (9.40, 6.15), (8.87, 5.20), (8.50, 4.20)	(17.67, 4.05), (17.67, 4.05), (17.67, 4.05), (17.67, 4.05)	(38.02, 5.77), (38.02, 5.26), (38.03, 4.25), (38.16, 4.05)	(71.89, 10.22), (71.82, 9.82), (70.67, 8.50), (70.75, 8.58)
XNN	7	15	36	67
XMM	12	20	40	73
YNN	3	1	1	5
YMM	10	8	10	11
NI	15	8	12	9
TP	T-10	T-3	T-7	T-6

Fig.5



	PS1	PS2	PS3
XN	7	36	68
XM	20	40	73
YN	1	1	6
YM	8	3	11
C	(13.5, 4.5)	(38.0, 2.0)	(70.5, 8.5)
CG	(15.63, 3.93)	(38.10, 2.20)	(71.5, 9.5)
P	P1, P2	P3	P4
XNN	7	36	67
XMM	20	40	73
YNN	1	1	5
YMM	10	10	11
NI	15	12	9
TP	T-10	T-7	T-6
CONT	NO	NO	NO
SAP	AR	AR	AR

Fig. 6