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(54) **ACCESS CONTROL DEVICE FOR A PERSON AND/OR A MOVABLE OBJECT AND METHOD FOR CONTROLLING THE OPENING AND/OR CLOSING OF A BLOCKING DEVICE**

(57) The invention refers to an access control device for a person (12) and/or a movable object (14), comprising a blocking device (18) configured to be, after receiving an opening signal, in an open state in which the person (12) and/or the movable object (14) can pass the blocking device (18) and to be, after receiving a closing signal, in a closed state in which the blocking device (18) blocks the person (12) and/or the movable object (14) from passing the blocking device (18), a control device (22) configured to generate the opening signal and/or the closing signal, and an imaging device (20) configured to image the blocking device (18) and a vicinity thereof, the imaging device (20) being in data communication with the control device (22), wherein the control device (22) is configured to identify the person (12) and/or the movable object (14) in the image generated by the imaging device (20), and wherein the control device (22) is configured to generate the closing signal if the control device (22) has determined that the identified person (12) and/or movable object (14) has passed the blocking device (18) and/or the control device (22) is configured to generate the opening signal if the control device (22) has determined that the identified person (12) and/or movable object (14) is in front of the blocking device (18).

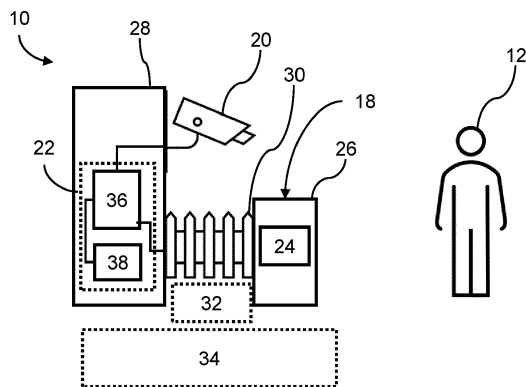


Fig. 1

Description

[0001] The present invention relates to access control device for a person and/or a movable object. The access control device comprises a blocking device configured to be in an open state in which the person and/or the movable object can pass the blocking device and to be in a closed state in which the blocking device blocks the person and/or the movable object from passing the blocking device.

[0002] The invention further refers to a method for controlling the opening and/or closing of a blocking device. The blocking device is configured to be in an open state in which a person and/or a movable object can pass the blocking device and in a closed state in which the blocking device blocks the person and/or the movable object from passing the blocking device.

[0003] Access systems for persons (which are sometimes called checkpoints) are known from the prior art. They can comprise means for the detection and evaluation of access authorization as well as mechanical blocking devices, for example in the form of turnstiles, sliding doors, lifting-sliding doors or so-called flap gates, whereby the blocking devices are actuated in the presence of a valid access authorization. The blocking device may be configured as described in EP 3 660 793 A1 which is incorporated by reference in its entirety.

[0004] The present invention is based on the objective of providing an improved mechanism for reliably and securely opening and/or closing a blocking device.

[0005] This objective is solved by the subject matter of the independent claims. Optional embodiments are described in the depending claims.

[0006] The invention refers to an access control device for a person and/or a movable object which comprises a blocking device, a control device, and an imaging device. The blocking device is configured to be, after receiving an opening signal, in an open state in which the person and/or the movable object can pass the blocking device and to be, after receiving a closing signal, in a closed state in which the blocking device blocks the person and/or the movable object from passing the blocking device. The control device is configured to generate the opening signal and/or the closing signal. The control device is in data communication with the blocking device. The imaging device is configured to image the blocking device and a vicinity thereof. The imaging device is in data communication with the control device. The control device is configured to identify the person and/or the movable object in the image generated by the imaging device. The control device is configured to generate the closing signal if the control device has determined that the identified person and/or movable object has passed the blocking device. Alternatively or additionally, the control device is configured to generate the opening signal if the control device has determined that the identified person and/or movable object is in front of the blocking device.

[0007] The invention further refers to a method for con-

trolling the opening and/or closing of a blocking device. The blocking device is configured to be in an open state in which a person and/or a movable object can pass the blocking device and in a closed state in which the blocking device blocks the person and/or the movable object from passing the blocking device. The method comprises the steps of imaging the blocking device and a vicinity thereof, identifying the person and/or the movable object in the generated image, and executing one or both of the following steps: bringing the blocking device to the closed state when the identified person and/or movable object has passed the blocking device and/or bringing the blocking device to the open state when the identified person and/or movable object is in front of or close to the blocking device.

[0008] The principal idea of this invention is to control the blocking device to be either in the closed state or the open state depending on information that is gathered from the image taken by the imaging device or information that is generated by the imaging device. The invention can be used in addition to or as a replacement of commonly used sensors for detecting the presence of the person and/or a movable object at the blocking device or in the vicinity of the blocking device. For example, the images taken by the imaging device can be used to determine whether it is possible to safely close the blocking device, i.e. to assess whether the closing of the blocking device would collide with the person and/or movable object. Further, the invention may be used to determine when the blocking device needs to be put in the open state so that the person and/or the movable object can pass the blocking device.

[0009] Up until now, persons and/or movable objects have been monitored using light barrier sensors with blocking devices such as turnstiles. Light was emitted and reflected by the person and/or movable object towards a light sensitive sensor. Further radar sensors for monitoring a larger area and a higher number of persons passing by the blocking device. However, with these commonly known systems, the determination of a "group of objects" (e.g. various persons and/or moving objects) is difficult to be implemented using radar sensors and/or light barriers. These systems deliver a "yes/no" information about presence of objects in the space monitored. Advanced sensors may additionally provide distance information. Nevertheless, the number of sensors used is usually limited, for example 2 or 4 sensors. With this limited number of sensors, only little information is available to determine localization information on the "group of objects" such as where the "group of objects" is located. For example, detecting the belonging of a child to an adult is very difficult with these sensors, since needed gaps are not always provided between the adult and the child. These drawbacks of the commonly used sensors can be overcome by using the imaging device since this idea allows to determine the location of a person and/or movable object even within a group. This is helpful to precisely control the blocking device.

[0010] Further, the imaging device may be arranged offset or above the blocking device so that the imaging device is less error prone. For example, dirt or scratches on the sensors due to contact with the person and/or movable object may render the sensors non-functional. This risk is reduced if the imaging device is arranged out of reach of the person and/or movable object which is not possible with light barriers.

[0011] The blocking device may comprise one or more mechanical blocking elements, for example in the form of turnstiles, turnstiles with one, two or three blocking arms, sliding doors, lifting-sliding doors, so-called flap gates, gates, barriers and/or bounds. The blocking element can include a bend bar. One or more spindles can rotate in opposite direction to bend the bar. This is described in EP 3 660 793 A1.

[0012] The person may be an adult, a teenager, or a child that wants to pass the blocking device for getting access to a restricted area. The restricted area may be a security zone (e.g. at airports), stadium, or any other event venue. The movable object may be a bicycle, wheelchair, pram, buggy, and/or baby carriage which is moved by the person. Further, the movable object may be a vehicle. In this case, the blocking device may include a barrier for example for a parking space. So, the restricted area may be a parking space.

[0013] The blocking elements may only be in the open state in case of a valid access authorization which can be checked by the interaction of the access control device with a ticket or other means of an authorization token. The access control device allows and/or denies access to the restricted area.

[0014] The access control device may include two or more blocking devices each of which can be configured to control access to the restricted area. For example, each blocking device controls the access for a respective passage that can be blocked by the respective blocking device.

[0015] In this disclosure, the open state of the blocking device is considered to be a state or configuration of the blocking device in which the person and/or movable object can pass the blocking device. In other words, the person and/or movable object can access an area that is restricted by the blocking device. This is in contrast to the closed state of the blocking device. In this disclosure, the closed state of the blocking device is considered to be a state or configuration of the blocking device in which the person and/or movable object is prevented from passing the blocking device. In other words, the blocking device prevents the person and/or movable object from passing the blocking device and accessing the area restricted via the blocking device.

[0016] There are at least three configurations or examples of the open state: (i) the blocking device is configured to be manually opened by the person and/or the movable object, (ii) the open state includes that the blocking device is maintained or continues to be in an open position, or (iii) the blocking device is (actively) moved to the open

position.

[0017] In the first example of the open state, the person and/or movable object may manually open the blocking device. For example, the blocking device is in an unlocked state which allows manual actuation of the blocking device by the person and/or the movable object. For example, turnstiles are unlocked so that the person can rotate the turnstiles or gates of the blocking device are unlocked so that the person can manually open the gates.

[0018] In the second example of the open state, the blocking device is permanently in an open position in which the blocking device is in such a position or orientation that the person and/or movable object can pass the blocking device. For example, in the open position, the barrier, the sliding door, and/or the gate are positioned such that an entrance or access defined by the blocking device is not closed by the barrier, the sliding door, or the gates, respectively. The blocking device can remain to be in the open position for allowing smooth access of the person and/or the movable object until the blocking device receives the closing signal. In this case, the person and/or the movable object does not need to wait for the blocking device to be put in the open position but remains permanently open until the closing signal is received.

[0019] In the third example of the open state, the blocking device is in the closed position and receives the opening signal upon which the blocking device is actively moved to the open position. This means that the blocking device is in the closed position until the blocking device is actively opened upon receiving the opening signal. So, the difference between the second example and the third example of the open state is the position of the blocking device when receiving the open signal. In the second example, the blocking device is in the open position whereas, in the third example, the blocking device is in the closed position. Upon receiving the opening signal, the blocking device is actively moved to the open position in the third example, whereas no actuation of the blocking device occurs in the second example. There are at least two configurations or examples of the closed state: (i) the closed state includes that the blocking device is locked to a closed position or (ii) that the blocking device is moved to the closed position.

[0020] In the first example of the closed state, the closed state includes a situation in which the blocking device is locked, e.g. cannot be manually opened by the person. For example, turnstiles can no longer be rotated by the user upon receiving the closing signal.

[0021] In the second example of the closed state, the closed state can also refer to the closed position in which the blocking device is actively closed upon receiving the closing signal. For example, the closing signal is generated if it is determined that the person and/or the movable object has passed the blocking device so that the blocking device can return to the closed position from the open position.

[0022] The blocking device may comprise a first block-

ing element and a second blocking element. The blocking device may comprise a first supporting device and/or a second supporting device. The first supporting device can support, allow movement of, and/or move the first blocking element from the open position to the closed position. The second supporting device can support, allow movement of, and/or move the second blocking element from the open position to the closed position. The access to restricted area (e.g. a passage) may be provided between and/or is limited by the first supporting device and the second supporting device.

[0023] The first supporting device and/or the second supporting device may include an actuator, such as an electric motor, for moving the first blocking element and the second blocking element, respectively. Alternatively or additionally, the first supporting device and/or the second supporting device may comprise locking means for locking and unlocking the first blocking element and/or the second blocking element, respectively. In an unlocked state (an example of the open state), the first blocking element and/or the second blocking element can be moved (e.g. from the closed position to the open position or rotated in case of a turnstile) by the person and/or the movable object. In a locked state, the first blocking element and/or the second blocking element cannot be moved (e.g. from the closed position to the open position or rotated in case of a turnstile) by the person and/or the movable object.

[0024] The control device can include a processor and/or a memory. The memory may store programs, algorithms and/or other types of software which can be executed by the processor. The control device can execute programs, algorithms and/or other types of software which can execute functionalities of the access control device described herein. The control device is in data communication with the blocking device for controlling the blocking device. The control device may further be in data communication with the imaging device for receiving the images (image information) taken by imaging device and/or for controlling the imaging device such as changing the direction and/or focus of the imaging device, e.g. for focusing the imaging device on the person and/or object. The data communication between the control device, the blocking device and/or the imaging device may be implemented by a wireless communication and/or be wires connecting these devices.

[0025] The control device may be electrically and/or electronically connected to the first blocking element, the second blocking element, the first supporting device, and/or the second supporting device, optionally to the actuator and/or the locking means. Thus, the open signal and/or the closing signal can cause a change in the state of the first blocking element and/or the second blocking element.

[0026] The control device may be arranged within a housing of the blocking device or can be remote to the blocking device. For example, the control device may control a plurality of blocking devices and/or a plurality

of imaging devices. The control device may include a computer or server arranged remote of the blocking devices. The control device may be arranged in a housing of the blocking device, e.g. in a housing of the first and/or second supporting device.

[0027] The imaging device can include one or more cameras and/or video cameras for imaging the blocking device and the vicinity of the blocking device, e.g. the person and/or a movable object approaching the blocking device, being at the blocking device, and/or leaving the blocking device. The imaged vicinity may include one or more areas of interest which may be close to and/or directly adjacent to the blocking device. The imaging device may image a predetermined area, or the imaging device may be configured to change the direction of imaging and may have a changeable focus. For example, the video camera firstly images a large area and, if a person and/or movable object is detected, the imaging device focusses on the person/or movable object by changing the imaging direction and/or changing the focus.

[0028] The one or more cameras may periodically take images. The periodicity may be changed upon the detection of a person and/or movable object. For example, the rate of images taken may be increased if a person and/or movable object is detected for better monitoring the movement and/or position of the person and/or movable object.

[0029] The video camera may generate video stream (i.e. a stream of images). The video camera may start generating a video stream after a person and/or movable object is detected, for example by using the camera and/or by firstly taking images using the video camera.

[0030] The images and/or video stream may be stored in a processing buffer of the camera and is then forwarded to the control device. The images and/or video stream may be directly stored with the control device for analysis but is not permanently recorded. For example, the video stream and/or images are stored only for the process of identifying persons and/or videos and their locations.

[0031] The (video) camera may include one or more optical sensors for obtaining image data indicative of the person and/or the movable object. The image video data can be in such a format that they can be processed by the control device. For example, the control device can be configured to process the image data for generating a video and/or image of the person and/or the movable object.

[0032] The imaging device may include two or more (video) cameras each of which can be configured to generate (video) images of different areas. The imaged areas may partially overlap or are separated from each other. For example, each (video) camera images an area associated with a blocking device. The (video) cameras may be arranged to generate a bird's view image of the blocking device. Further, one (video) camera may be configured to image a person and/or movable object approaching the blocking device, one (video) camera may

be configured to image a person and/or movable object passing the blocking device, and/or one (video) camera may be configured to image a person and/or movable object leaving the blocking device.

[0033] The control device is configured to process the image data generated by the imaging device in order to identify a person and/or a movable object in the images (or image data) generated by the imaging device. Commonly used techniques can be applied, for example artificial intelligence (AI) and/or neural networks which can be executed by the control device. Using AI, it is possible to reliably detect a person, a bike and/or any other (known) objects. For example, a network like YOLOv5 can be used that analyses the video stream (an example of image data or image) frame by frame for detecting the person and/or movable object.

[0034] Once the control device identified a person and/or movable object, the control device can further be configured to determine whether the identified person and/or movable object is in front of the blocking device (i.e. this indicates that the blocking device needs to be put in the open state so that the person/object can pass the blocking device). In this case, the control device sends the opening signal to the blocking device upon which the blocking device is set to the open state so that the person and/or the movable object can pass the blocking device. The opening signal may be generated when it is determined that the identified person and/or movable object is in a predetermined area in front of the blocking device.

[0035] Further, the control device can be configured to determine whether the identified person and/or movable object is at the blocking device (e.g. the person and/or movable object would interfere with the movement of the blocking device from the open position to the closed position) and/or whether the identified person and/or movable object has passed the blocking device (e.g. the person and/or the movable object would no longer interfere with the movement of the blocking device from the open position to the closed position). If it is determined that the person and/or the movable object are no longer at the blocking device and/or have left the blocking device, the control device generates the closing signal which puts the blocking device in the closed state (e.g. blocking device is moved from the open position to the closed position). The closing signal may be generated when it is determined that the identified person and/or movable object is in a predetermined area behind the blocking device.

[0036] The control device may extract real-world coordinates of the person and/or the movable object from the images or the image data. For example, the position and/or the orientation of the imaging device is known which can be used to determine the real-world coordinates of the person and/or the movable object. Alternatively or additionally, particular positions (e.g. real-world coordinates) within the viewing range of the imaging device are known which can be linked to the identified per-

sons and/or movable object to determine the real-world coordinates. The determined real-world coordinates can be used to determine whether the identified person and/or movable object is in front of, at, and/or has passed the blocking device.

[0037] Alternatively or additionally, the control device may determine the position of the identified persons and/or movable object in relation to the blocking device. This means that the control device may not determine real-world coordinates of the identified person and/or the movable object but rather to check whether the distance between the identified person and/or movable object and the blocking device is above or below a certain threshold.

[0038] In both cases, the control device can be used for safeguarding that the operation of the blocking device (such as a movement of the blocking element from the open position to the closed position) does not contact or harm the person and/or the movable object. Alternatively or additionally, the control device can be used to determine when the blocking device needs to be put in the open position (e.g. be operated from the closed position to the open position) because the person and/or the movable object is in front of or close to the blocking device.

[0039] The determination that the person and/or movable object is in front of, close to, at, behind, and/or has passed the blocking device (e.g. the blocking element) can be implemented by determining whether the person and/or movable object is within a predetermined zone (e.g. a zone corresponding to the range of actuation of the blocking element or an entrance zone) and/or within or outside a certain distance between the blocking device (e.g. the blocking element) and the person and/or movable object. For example, a distance below a threshold distance indicates that the person and/or movable object is close to or in front of the blocking device.

[0040] In an optional embodiment, the imaging device is further configured to image an entrance zone in front of the blocking device. The control device may be configured to track the movement of identified persons and of objects in the entrance zone for determining when the opening signal is to be generated.

[0041] The entrance zone may be an area which the person and/or the movable object need to pass, cross, or transit for reaching the blocking device. The entrance zones of two or more blocking devices may overlap. The blocking device may define a passage which is blocked by the blocking element in the closed position. The control device may generate the opening signal if the person and/or movable object are determined to have entered the passage (and are therefore directly in front of the blocking element). The entrance zone may be an area adjacent to the passage or a section of the passage remote of the blocking element (in cases, where the passage is long).

[0042] For tracking the person and/or movable object, the control device may be configured to identify the same person and/or movable object in each frame of the video stream or in consecutive images and determine changes

in the positions of the respective person and/or movable object. Tracking the movement of the person and/or movable object may be used to predict the future movement of the identified person(s) and/or movable object(s), for example when or at which blocking device identified person and/or movable object will arrive. This may be used to ensure that the blocking device is not prematurely set to the open state (so that a non-eligible person and/or movable object can pass the blocking device) and/or that the blocking device is put in the open state just in time (so that the person and/or movable object does not need to stop in front of the blocking device because it is still in the closed state). This may provide a smoother passage of the blocking device allowing for more persons and/or movable objects passing the blocking device in a certain period of time.

[0043] The prediction of the future movement of the person and/or movable object can be based on the velocity (by determining changes in the position in previous frames and/or images), the current position, and/or the direction of movement of the person and/or movable object (by determining changes in the position in previous frames and/or images).

[0044] In an optional embodiment, the control device is configured to place a virtual bounding box around the identified person and/or movable object, the bounding box indicating dimensions of the identified person and/or movable object. Optionally, the control device is configured generate the closing signal if the control device has determined that the bounding box has passed the blocking device, and/or the control device is configured generate the opening signal if the control device has determined that the bounding box is in front of or close to the blocking device.

[0045] The virtual bounding box (or boundary box) may have predetermined shape, e.g. a cuboid. The bounding box can also have a more nuanced shape with regard shape of the person and/or the movable object. For example, the virtual bounding box may be an aggregation of different predetermined shapes which are combined with each other to resemble the identified person and/or movable object. The virtual bounding box once assigned to the person and/or the movable object may not be changed, e.g. for following frames or images. In other words, the same virtual bounding box may be used for the same person and/or movable object in the various frames of the video stream and/or images. This may simplify tracking of the person and for the raw movable object. The person and/or movable object may be tracked by monitoring changes in the position of the virtual bounding box.

[0046] The dimensions of the bounding box may be chosen in that the complete identified person and/or movable object is within the virtual bounding box. This has the optional advantage that the person and/or movable object reliably is completely within bounding box (this can enhance the safety of the access control device as further described below). For example, the bounding box has a

predetermined shape (e.g. the shape is stored in a memory and is used for every person and/or movable object that is identified) or the bounding box for each type of person and/or movable object may have predetermined shape (e.g. a cuboid). The dimensions of the bounding box are chosen so that the person and/or movable object is completely within the bounding box. In another example, the shape and dimensions of the bounding box are adapted so that the person and/or the movable object are completely within the bounding box. This can provide a bounding box with reduced volume (resulting in a more accurate assessment). However, this approach requires more computational work compared to a predetermined shape of the bounding box.

[0047] In a further embodiment, the dimensions of the bounding box are preset depending on whether it is a person and a movable object, optionally on the type of movable object. For example, each bicycle identified in the image has the same bounding box and each stroller identified in the image has the same bounding box irrespective of whether these objects completely fit within the bounding box. For example, a dimension of the present bounding box may be chosen so that the identified persons and/or movable objects are very likely to completely fit within the bounding box, for example by 90%, 95 %, 99%, or 100%.

[0048] The virtual bonding box can be considered a means for determining a position and/or a sphere of activity of a person and/or movable object. So, if the virtual bonding box is determined to be outside of a range of actuation of the blocking element, the blocking element can be safely operated. The bounding box is virtual which means that the bounding box is a tool or measure applied to the image data and/or can be virtually added to the image or video stream. For example, the control device identifies a person and/or movable object in the image, applies the virtual bounding box, and uses the virtual bonding box for determining if and when to generate the closing/opening signal. In other words, the generation of the opening and/or closing signal is not determined using the position and/or shape of the person/movable object, but by using the virtual bounding box. The person and/or movable object can only be identified for determining shape and/or position of the bounding box.

[0049] The control device may be configured to determine the position of the bounding box similar to the above-described determination of the position of the person and/or the movable object. The control device may be configured to generate the opening signal when a side surface of the bounding box is within a certain threshold distance to the blocking element or blocking device. Similarly, the control device may be configured to generate the closing signal if it is determined that the bounding box is not within an operation range of the blocking element or a side surface of the bounding box is outside a certain threshold distance to the blocking element or blocking device.

[0050] In an optional embodiment, the control device

is configured to determine a group of person(s) and/or movable object(s) in the image generated by the imaging device by determining a distance between the person(s) and/or movable object(s) in the image.

[0051] A group of person(s) and/or movable object(s) may include an adult and a child, a plurality of persons, a person and a movable object (such as a bike, wheelchair, or stroller), or a vehicle and a trailer.

[0052] A group of person(s) and/or movable object(s) have usually in common that a distance between the group members is less than a distance between persons and/or movable objects not belonging to this group (e.g. belonging to a different group). So, a group of person(s) and/or movable object(s) may be identified if a distance between the person(s) and/or movable object(s) is below a (predetermined) threshold. The determination of a group may be useful for generating the opening and closing signal. For example, the closing signal is generated once the complete group of person(s) and/or movable object(s) has passed the blocking device. Further, the opening signal is generated if the complete group is in front of the blocking device.

[0053] The above-described determination of a group can be more reliable than using light barriers or radar sensors because individual members of the group can be identified. Light barriers and radar sensors may not be capable of determining individual group members in case if the distance between the group members is too small - two close group members may be identified as a single group member which may result in a too late generation of the closing/opening signal.

[0054] The distance may be measured between a centre point of the identified person and/or movable object (such as a geometrical centre point or centre of gravity) or a part of the identified persons and/or movable object that is closest to the other person and/or movable object. Further, the change in the position of geometrical centre point or the centre of gravity of the person/movable object or their bounding box may be used to track the person and/or movable object.

[0055] In an optional embodiment, the control device is configured to determine the distance by using the bounding boxes, optionally a centre point of the bounding boxes.

[0056] The bounding boxes of the group members may overlap because the bounding boxes are usually larger than the volume/shape of the person and/or movable object. In this case, it is preferred to compare centre points of the bounding boxes. The centre point may be a geometrical centre point of the bounding box or may correspond to a centre of gravity of the bounding box. Further, the centre point of the bounding box may be predetermined for each bounding box. The distance between the members of a group can also be determined by comparing a distance between side surfaces of two members of the group.

[0057] The overlapping bounding boxes may be combined to form a group bounding box. In more general, a

single bounding box (e.g. the group box) may be used instead of or in addition to the individual bounding boxes of the group members. The group bounding box may be made up by outer surfaces of the bounding boxes of the individual members of the group. Alternatively, the group bounding box is established similar as described above in connection of the bounding box for an individual group member. The only difference can be that all group members are used instead of a single group member. For example, the dimensions of a predetermined shape of the group bounding box is adapted to the detected group. In an optional embodiment, the control device generates the closing signal if the group bounding box is determined to have passed the blocking device and/or generates the opening signal if the group bounding box is determined to be in front of the blocking device.

[0058] In an optional embodiment, the control device is configured to determine that the person(s) and/or movable object(s) belong to a group if a distance is below a first threshold or if a distance is below a second threshold for a predetermined number of times.

[0059] The first threshold may be smaller than the second threshold. The first threshold may indicate that the persons of the group know each other. In this case, group members usually stand and/or walk closer to each other compared to persons that do not know each other. Further, a distance between a person and a movable object such as a bike is usually small since the person handles and/or holds the movable object. The person(s) and/or movable object(s) may be identified as belonging to a group if the distance between the person(s) and/or movable object(s) is once below the first threshold.

[0060] The second threshold may relate to the fact that members of a group are close to each other over a period of time. That is why the distance between the person(s) and/or movable object(s) needs to be below the second threshold for a predetermined number of times, e.g. over a predetermined number of frames of a video stream and/or a pre-number of images subsequently taken by imaging device. The number of times reflects the duration over which the members of the group need to be close to each other. The second threshold may be a more reliable measure if the group consists of several persons (which usually change their distance over time) and/or if there are many persons and/or movable objects close to the blocking device (e.g. in a crowded space) so that at some points the distance between person(s) and/or movable object(s) is smaller than the first threshold although these person(s) and/or movable object(s) do not belong to a group.

[0061] Using the second threshold may encompass that the distance between the person(s) and/or movable object(s) is larger than the second threshold at some point(s) as long as the distance between the person(s) and/or movable object(s) is below the second threshold the predetermined number of times in a predetermined time range. This means that the distance between the person(s) and/or movable object(s) is below the second

threshold for x times among y measured times, whereby $x < y$.

[0062] A further indication that person(s) and/or movable object(s) belong to a group is that if the individual group members start moving at the same or similar time, stop moving at the same or similar time, have the same or similar acceleration, and/or have the same or similar deceleration. These parameters may be gathered by tracking the group members. In more general, a similar movement pattern of two or more person(s) and/or movable object(s) indicates that these person(s) and/or movable object(s) belong to the same group. For example, a bicycle pushed by a person is expected to have the same velocity, acceleration, and/or start or stop times as the person.

[0063] In an optional embodiment, the control device is configured to classify the identified persons and/or movable object into one of a plurality of types.

[0064] A type of person may include an adult, a teenager, and/or a child. A type of movable object may include a bicycle, a pram, buggy, and/or baby carriage, a vehicle, a truck, a lorry, and/or a trailer. The types of person and/or movable object may be predetermined, e.g. stored with the control device. For example, the predetermined types of person and/or movable object may be those that were used for training the neural network run by the control device. This may mean the neural network is configured to identify only certain types of person(s) and/or movable object(s) and classify the identified of person(s) and/or movable object(s) accordingly.

[0065] The control device may be configured to identify the type of the person and/or the movable object by the shape of the virtual bounding box that is applied to the identified person and/or movable box. For example, the shapes of the movable box of the person and a bicycle greatly differ which may be used as an indication for the type of the person and/or movable object. Alternatively, the control device may be configured to firstly identify the type of person and/or movable object and, subsequently, apply a virtual bounding box that corresponds to the type of person and/or movable object. For example, the control device may be configured to store a virtual bounding box for each type of person and/or movable object.

[0066] The control device may be configured to actively determine the type of person and/or movable object, for example by analysing the images generated by the imaging device. For example, the control device may use a commonly known software and/or program that is configured to identify persons and/or movable objects in an image. Optionally, the control device may include an AI and/or neural network that has been trained for identifying a person and/or a movable object in the image and, in a second step, identify the type of person and/or movable object or vice versa.

[0067] In an optional embodiment, the control device includes a memory configured to store a plurality of combinations of different types. Optionally, the control device is configured to determine that the person(s) and/or mov-

able object(s) belong to a group if a distance is below a third threshold and if the respective types are equal to one of the stored combinations.

[0068] The types of combination may include a person (adult) and a bike, an adult and a child, a person (adult) and a pram, buggy, and/or baby carriage, and/or a vehicle and a trailer. The types of combination may be stored in the memory of the control device in advance and can reflect the types of combination that are expected at the blocking device.

[0069] The third threshold may be larger than a second threshold or the third threshold may be larger than the first threshold and smaller than the second threshold. The types of combination indicate person(s) and/or movable object(s) which usually form a group. So, in one embodiment, the determination of a group can be used without determining a distance, i.e. by simply checking whether the group members correspond to the stored combination of types. However, the determination of a group can be more reliable if the combination of types is associated with the third distance. In other words there are two criterions: (i) the person(s) and/or movable object(s) correspond to one of the stored combination of types and (ii) the distance between the person(s) and/or movable object(s) is below the third threshold. Further, the identification that a person(s) and/or movable object(s) belongs to a group can be associated with a third criterion which is that the distance between the person(s) and/or movable object(s) is below the third threshold over a predetermined number of times. Similar considerations as discussed in conjunction with the second threshold equally apply.

[0070] In an optional embodiment, the blocking device is further configured to be, after receiving an intermediate signal, in an intermediate state which provides partial access. Optionally, the control device is further configured to generate the opening signal or the intermediate signal depending on the number of group members and/or the type(s) of the group members.

[0071] In an optional embodiment, the blocking device includes a first blocking element and a second blocking element, the first blocking element and the second blocking element being positioned adjacent to each other for defining a common access and the first blocking element and the second blocking element being each configured to be, after receiving the open signal and/or the closing signal, in the open state and the closed state, respectively. Optionally, the control device is configured to control the first block element and the second blocking element independently from each other. Further optionally, the control device is further configured to generate the opening signal for the first blocking element and/or the second blocking element depending on the number of group members and/or the type of the group members.

[0072] The first blocking element and the second blocking element are positioned adjacent to each other for defining a common access or a single passage. For example, the blocking device includes a passage which

can be commonly blocked by the first and the second blocking elements. The first and second blocking elements can be controlled jointly or separately. An example for the separate control is that the partial access is provided (e.g. the intermediate state) by setting the first blocking element in the open state (by sending the opening signal to the first blocking element) and the second blocking element in the closed state (by sending the closing signal to the second blocking element). For example, the first blocking element may be configured to provide access for a person and the second blocking element may be configured to provide access for a movable object such as a bicycle. The intermediate state may therefore relate to setting the first blocking element to the open state such that only a person but not a person with a bicycle can pass the blocking device.

[0073] An example for the joint control is that both the first and second blocking element are in an intermediate position which is between the open position and the closed position. In this case, both the first blocking element and the second blocking element do not completely block their respective passages so that the first blocking element and the second blocking element commonly provide an access which has the dimensions similar to the access provided by the first blocking and/or the second blocking element.

[0074] The first blocking element and the second blocking element can define a first access and second access, respectively. The first access may be blocked by the first blocking element in the closed state and the second access may be blocked by the second blocking element in the closed state. The first blocking element can allow passage through the first access in the open state of the first blocking element. The second blocking element can allow passage through the second access in the open state of the second blocking element.

[0075] The first access and the second access commonly define the common access. The common access is a continuous access, for example the first access and the second access are not separated by further (permanent) mechanical means. Thus, if the first blocking element and the second blocking element are in the open state, passage through the common access is possible. Thereby, the person and/or the movable object can use the width of the sum of the widths of the first access and the second access. In other words, the common access can have a width that is the sum of a width of the first access and of a width of the second access. Optionally the width of the first access and the width of the second access are not separated and, thus, are directly adjacent to each other.

[0076] The width of the common access may define the maximal width of the person and/or movable object that can move through the access control device. The sum of the widths of the first blocking element and the second blocking element can define the width of the common access and, thus, define the maximal width of the person and/or movable object that can move through the

blocking device. The maximal width of the person and/or movable object that can move through first access and the second access can be defined by the width of the first blocking element and the second blocking element, respectively.

[0077] The common access is defined by the first blocking element and the second blocking element. The common access is open when passage of the person and/or movable object through the common access is possible. In other words, the common access is open if the first blocking element and the second blocking element are in the open state (i.e. if the first blocking element and the second blocking element allow access).

[0078] The control device can generate the opening signal or the intermediate signal depending on the number of group members. For example, if the number of the members of a group is above a certain threshold, for example 3, 4, 5, the control device generates the opening signal to the blocking device, e.g. sends the opening signals to the first blocking element and the second blocking element. This increases the number of persons that simultaneously can pass the blocking device since both the first blocking element and the second blocking element are in the open position. If however the number of members of the group are below the threshold, the control device sends the intermediate signal to the blocking device (e.g. sends an opening signal to the first blocking element and a closing signal to the second blocking element) so that only one of the first and second blocking elements can be used for passing the blocking device. In this way, the access of the person can be reliably controlled.

[0079] In another example, the control device sends the opening signal to the blocking device (e.g. to the first blocking element and the second blocking element) if it is determined that the group includes a person and a movable object such as a bike. In this case, the person with the bike can pass the blocking device. If however, only a person or a group of persons are in front of the blocking device, the control device sends the intermediate signal (e.g. sends an opening signal to the first blocking element and a closing signal to the second blocking element) so that only the person(s) can pass the blocking device but not a person with movable object such as bicycle.

[0080] In an optional embodiment, the control device is configured to generate a first closing signal to bring the first blocking element in the closed state if the control device has determined that a first identified person or movable object has passed the first blocking element and/or to generate a second closing signal to bring the second blocking element device in the closed state if the control device has determined that a second identified person or movable object has passed the second blocking element.

[0081] With this embodiment, the control device is configured to separately close the first blocking element and the second blocking element so that each blocking ele-

ment is immediately closed once the person and/or the movable object has passed the respective blocking element. For example, a bicycle is usually longer than a person so that the blocking element for the person can be closed earlier compared to the blocking element for the bicycle. So, the control device generates the first closing signal once the person has passed the first blocking element and generates the second set closing signal once the bicycle has passed the second blocking element.

[0082] The first closing signal can be sent to actuate the first blocking element for setting this first blocking element to the closed state and the second closing signal can be sent to the second blocking element for setting this second blocking element to the closed state.

[0083] In an optional embodiment, the access control device further comprises an interface device configured to generate an access request signal upon receiving an access request, the access request includes a number for each type permitted to pass the blocking device. Optionally, the control device is configured to determine the number of each type in a group after receiving the access request. Further optionally, the control device is further configured to generate the opening signal if the control device has determined that number of types for each type determined by the control device is smaller than or equal to the number of a respective type in the access request.

[0084] The interface device can be provided for recognising, obtaining, and/or detecting access requests by the person and/or the movable object. The access requests may be executed by inputting information into the interface device, paying an access fee, presenting a ticket, and/or presenting other types of access means which can be recognised/detected by the interface device. Upon recognition of an access request, the interface device generates an access request signal that is transmitted/forwarded to the control device. The access request signal may comprise any type of data that allows the determination that a particular access request is submitted to the interface device. For example, the access request signal may include information who and/or what has a valid access, the number of person(s) and/or movable object(s) that have a valid access, the type of person(s) and/or movable object(s) that have a valid access, the time of access, etc.

[0085] The interface device may include a first reading device coupled to the first blocking element and/or a second reading device coupled to the second blocking element. However, it is also possible that the interface device includes a single reading device coupled to both the first blocking element and the second blocking element. The interface device may be in data-communication with the control device.

[0086] The (first) reading device and/or the second reading device may include a scanner for scanning a ticket, an input device for inputting an access request (such as a touchscreen, buttons, a keyboard), a payment device for accepting cash and/or card payment, and/or

an antenna for detecting a token granting access. The (first) reading device and/or the second reading device may include reading devices for contactless reading of access authorizations, for example via a standard for wireless communication, such as RFID, NFC, WLAN, Bluetooth, BLE, UWB, and/or devices capturing biometric features, such as fingerprint scanners or cameras with facial recognition software.

[0087] The (first) reading device and/or the second reading device may electrically and/or electronically connected to the control device. The (first) reading device and/or the second reading device may be in data communication with the control device. The control device may be configured to start generating the opening signal (e.g. the first opening signal for the first blocking element and the second opening signal for the second blocking element) and/or the intermediate signal upon receiving the access request signal from the interface device. The interface device generates the access request signal when detecting/receiving an access request, for example by means of presenting a ticket, paying the access fee, and/or presenting the access authorizations described above. In other words, the generation of the opening signal and/or the intermediate signal may depend on the reception of the access request signal.

[0088] The first opening signal may be generated upon receiving an access request to pass the first blocking element. The second opening signal may be generated upon receiving an access request for passing the second blocking element. The access request may include a request for passing both the first and second blocking elements. Further, the control device can be configured to decide whether the first, the second, or both first and second blocking elements are put in the open state upon receiving the access request signal. For example, the access request may include information which allows the control device to generate the appropriate opening signal(s).

[0089] In a single mode, the presentation of an access request to the first reading device can result in an access granted by the first blocking element and the presentation of an access request to the second reading device results in an access granted by the second blocking element. This means the first blocking element and the second blocking element are controlled separately depending on an access request that is separately presented to the first reading device and the second reading device, respectively. This can be called autonomous operation in which it is possible to assign at least one reading device unambiguously to each blocking element.

[0090] Thereby, the access request stored on the ticket and/or on other types of tokens for access authorizations may include information that are detected/read/recognised by the first and/or second reading devices which result in the generation of the first and second opening signal, respectively. Thus, the respective opening of the first blocking element and the second blocking element essentially depends on the information that is read out

by the first and second reading devices. This can be considered an individual mode in which each person or movable object has a ticket.

[0091] In a group mode, a plurality of person(s) and/or movable object(s) share a ticket, for example, a family card which is valid for 2 adults and 2 children or a bicycle card which is valued for a person and a bicycle. In this case, it would be beneficial to control the number of person(s) and/or movable object(s) passing the blocking device.

[0092] This is done in that the control device determines the number of each type in the group after receiving the access request. For example, the control device determines the number of adults and/or children or the number of person(s) and/or movable object(s), e.g. a person and a bicycle. In a subsequent step, the control device checks whether, for each type, the number of types identified in the group is less or equal to the number of types as permitted by the access request i.e. as defined on the ticket. For example, when a family ticket is presented to the interface device, the control device checks whether the number of adults and the number of children in the group is less than the respective number allowed with the family ticket. In this example, the control device checks whether there are 2 or less adults in the group and whether there are 2 or less children in the group. If so, the control device issues the opening signal to the blocking device (e.g. a first opening signal for the first blocking element and/or the second opening signal for the second blocking element). If the control device determines that they are more than 2 adults or more than 2 children in the group, the control device does not send the opening signal to the blocking device or sends the closing signal to the blocking device if the blocking device is in the open state.

[0093] In general, the access request may include information that the allowed number of type A is x, the allowed number of type B is y, etc. Then, the control device checks in the group whether the number of person(s) and/or movable object(s) of type A is equal or less than x, whether the number of person(s) and/or movable object(s) of type B is equal or less than y, etc. If all these conditions are fulfilled, the control device sends the opening signal to the blocking device. If one or more of these conditions are not fulfilled, the control device does not send the opening signal to the blocking device or sends the closing signal to the blocking device if the blocking device is in the open state.

[0094] In an optional embodiment, the imaging device includes plurality of cameras which image the same area from different viewpoints. Optionally, the control device is configured to, for each camera, identify the person and/or the movable object in the respective image. Further optionally, the control device merges the results of the identifications for the respective cameras.

[0095] Using a plurality of cameras which image to same area can enhance the reliability of the identification of the person and/or the movable object. A person and/or

movable object may only be identified and/or classified if they are in the right orientation (or orientation range) to the camera. So, providing a plurality of cameras with different imaging directions increases the likelihood that one or more cameras have the right orientation (or orientation range) with respect to the person and/or movable object so that they can be identified and/or classified.

[0096] For example, the control device is configured to run the above-describe procedure of identifying a person and/or movable object, placing a virtual bounding box around them, and/or categorising the person and/or the movable object into a type for each image or video stream generated by a respective camera. So there are two or more procedure for the same person and/or object. For example, a person is considered identified if all or a majority of the processed images or revenue streams from respective cameras provide the same identification. Similar considerations may apply to the classification into a type and/or the detection of a group.

[0097] Optional aspects are described in the following: One problem that can be solved by the invention is the grouping of person(s) and/or movable object(s) into a single group which can access the blocking device as a group. This could be a parent with a stroller in front of them or a biker walking their bike through an access control device. A further problem that can be solved by the invention is to transfer this into operational commands for blocking device to let it react appropriately while the group is passing the access control device.

[0098] An aspect in this respect is identification of the person(s) and/or movable object(s) and their localization in respect to the blocking device. As a result, the access control device can be configured to deliver a signal to the blocking device when such a group is about to cross an access line of the blocking device and also when the group has partly or entirely passed the access line. So, it can be avoided that the blocking device is closed while the group has not entirely passed the access line (e.g. as defined by the blocking element(s) in the closed position). Further, the access line may be controlled by several blocking elements, which can in this case also to be controlled individually dependent how the group passes through.

[0099] The invention can include one or more of the following aspects:

- One or more cameras observing the access area (especially the area before the access line)
 - can be mounted in a bird's eye view, an arial view from various directions
- A processing unit or control device which runs a neural network in order to extract objects in the images
 - This control device might run on the camera itself

- A processing unit which is able to run the overall system which:
 - combines the person(s) and/or movable object(s) to one or more groups
 - tracks the groups
 - extracts the positions of groups
 - merges information from various cameras
 - sends signals to the blocking device
- the control device receives access control signals and evaluates them for appropriate operation

[0100] In each frame of a video, one or more of the following steps can be taken:

1. Detection and classification of the person(s) and/or movable object(s) in the frame
2. Semantic grouping of the person(s) and/or movable object(s) based on the rules which apply to the access situation
 - a. e.g. grouping a person with a bicycle when they are walking the bike towards the access control
3. Check if the groups have been detected in the frame before
 - a. If yes:
 - i. Check if the group is still the same (i.e. the same person(s) and/or movable object(s) are part of the group).
 1. If yes: Extend the existing track with the new position in the current frame
 2. If not: Generate a new track for the new constellation of the group(s)
 - b. If not: start a new track for the group of person(s) and/or movable object(s)
4. Extract the real-world position of each group (e.g. convert the position from camera to world coordinates)
5. Merge (and adapt) the results of all cameras which are observing the scene (i.e. in case more than one camera is used to increase the system's accuracy)
6. Check if a group is approaching the line of access (e.g. approximating the blocking device or blocking element)
 - a. If yes: send a signal to the control device to indicate that a group is about to pass (this could potentially open a blocking device or drive any other action)

7. Check if a group has passed an access line partially or completely

a. If yes:

- i. send a signal to the access system or related part of the access system indicating that a group or parts of the concerned group has passed through the access control
- ii. remove the group from the system to not further evaluate it.

[0101] In case the blocking device includes two or more blocking elements, the blocking elements may be separately controlled by the process shown above even if all elements are blocking only one lane together. The target can be, to directly close a blocking element, if the related part of the group has passed.

[0102] With regard to Step 1: the detection of the person(s) and/or movable object(s) and marking them can be done on a video stream e.g., rtsp stream. To this end, a network like Yolov5, published by Glenn Jocher, can be used that analyses the stream frame by frame. For each frame multiple types of person(s) and/or movable object(s) can be detected e.g., bike, person, trolley. These types can be reduced for specific objects in question. Each detected person(s) and/or movable object(s) can then be marked by a bounding box describing the coordinates of the area the object is in. The classification of the objects detected can be already done by the control device as this can assign a label to each detection, which is seen as most likely.

[0103] With regard to Step 2: the step of determining a group can be done by using coordinates to identify person(s) and/or movable object(s) that are in relation to each other. An example for finding a "biker" is a combination of two types of person(s) and/or movable object(s), e.g. a person and a bike, whereby the distance between the bike and the person can be an indication of the bike belonging to the person. Using the bounding boxes previously obtained, a distance between the coordinates can be calculated. If this distance is reasonable e.g., the bike will not be placed behind the person but pushed besides, the bike and the person can be considered belonging to a group. Additionally likelihood of combinations can be used to rate if two person(s) and/or movable object(s) are likely to belong to a group. For example, a person and a bike are more likely to belong together than a first bike and second bike without a person nearby. As mentioned in step 5, this can be an iterative process of evaluating whether the assigned group of person(s) and/or movable object(s) is still reasonable. This could be done like a tracking algorithm that is evaluated in each step.

[0104] The tracking in step 3 can be accomplished by using a state-of-the-art tracker. For example, a Euclidean distance tracker can be used successfully on a single person or movable object. These trackers can be adjusted such that a group of person(s) and/or movable ob-

ject(s) as well as a single person or movable object within the group can be tracked without any interruption. There are multiple trackers that could be suitable for this kind of task. However, it is preferred to use a multiple object tracker as these are designed for these types of use applications.

[0105] Another optional embodiment may fulfil one or more of the following tasks:

- The general idea of the invention may include providing a barrierless entry solution for persons using machine learning in combination with Ultra-wide-band (UWB).
- A target group, such as group of persons, are recognized in a video stream.
- To do so, the access control device can include one or more of the following features:
 - Camera placement, where the camera was located on the wall at a height of approximately 3 m
 - Definition of a region of interest (ROI) which can be an area of 2mx2m was marked. Within this ROI, person(s) and/or movable object(s) are detected and evaluated
 - Definition of successful entry. The closing signal is generated if the entry was denied i.e., no valid ticket was provided, and the opening signal is generated if the person(s) and/or movable object(s) are allowed to enter.
- For the detection of the person(s) and/or movable object(s), the YOLOv5 network, published by Glenn Jocher, is executed on the control device. This network can detect a variety of distinct types of person(s) and/or movable object(s) e.g., bike, person, car, tie etc. The control device can be simplified for only detecting persons.
- The control device takes an input stream and analyses it frame by frame. For each frame bounding boxes, coordinates of a box drawn around the detected object, are returned.
- When the bounding box is within the ROI a check for a valid ticket was started.
- Each bounding box, i.e., detected person(s) and/or movable object(s), may have a unique ID that was bound to this object until it left the ROI, which allowed to track the object without interruption.
- For the tracking of the person(s) and/or movable object(s), a Euclidean distance tracker can be used.
- When the person(s) and/or movable object(s) has a valid ticket, the associated ID can be linked to the ticket and an entry was granted. As soon as the person(s) and/or movable object(s) has crossed the entry line, the control device generates the closing signal.

[0106] The invention is explained in more detail below by way of example with reference to the accompanying

figures.

- Fig. 1 shows a schematic representation of a first embodiment of an access control device;
- Fig. 2 shows a schematic representation of a second embodiment of the access control device;
- Fig. 3 shows a schematic representation of a third embodiment of the access control device;
- Fig. 4 shows a schematic representation of a person pushing a movable object as identified in a video stream; and
- Fig. 5 shows a schematic representation of certain steps of a method for controlling the opening and closing of a blocking device.

[0107] Fig. 1 shows an access control device 10 for a person 12 and/or a movable object 14 which is configured to allow or deny access to a restricted area. The access control device 10 includes a blocking device 18, an imaging device 20, a control device 22, and/or an interface device 24.

[0108] The access control device 10 may provide an automatic gate at an airport or at an event location such as a sport stadium. The person 12 approaches the access control device 10 carrying a ticket. If the ticket is valid, the person 12 is granted or denied access to the restricted area by the access control device 10.

[0109] In the embodiment of Fig. 1, the blocking device 18 includes a first supporting device 26, a second supporting device 28, and/or a first blocking element 30. The first supporting device 26 and the second supporting device 28 define a passage 32 between them. The blocking element 30 can be in a closed position (shown in Fig. 1) in which the passage 32 is blocked by the first blocking element 30 so that the person 12 is restricted from accessing the restricted area. In other words, the first blocking element 30 blocks the passage 32 in the closed position. The closed position is an example of the closed state.

[0110] The blocking element 30 is supported by and movable to the first supporting device 26. For example, the first supporting device 26 includes an actuator for moving the first blocking element 30 from the closed position to an open position in which the person 12 can pass the passage 32 (the open position is an example of the open state). The actuator (not shown in Fig. 1) may be in electric motor or a locking means which is in data communication with the control device 22. So, the control device 22 can control the actuator and, therefore, the position or state of the blocking element 30.

[0111] For example, the control device 22 can generate and send an opening signal to the blocking device 18 which causes the blocking element 30 to be moved from the closed position to the open position, to maintain

the blocking element 30 in the open position, or to allow the person 12 to manually open the blocking element 30, for example by pushing the blocking element 30. The control device 22 can also generate and send a closing signal to the blocking device 18 which causes the blocking element 30 to be moved from the open position to the closed position or which locks the blocking element 30 such that the person 12 can no longer manually open the blocking element 30. The execution of the opening signal and the closing signal may be done by the actuator and/or the locking means of the blocking device 18.

[0112] The actuator and/or the locking means may be arranged within a housing of the first supporting device 26. The second supporting device 28 may house the control device 22 or may merely provide a physical component for delimiting the passage 32 together with the first supporting device 26. The first supporting device 26 and/or the second supporting device 28 may have the shape of a cuboid or a tower.

[0113] In the embodiment of Fig. 1, the imaging device 20 includes one or more video cameras that are configured to video image the blocking device 18 and a vicinity thereof. The imaging device 20 may image the passage 32 and an entrance zone 34 which is an area in front of the blocking device 18. If there are a plurality of video cameras, some or all of the video cameras may image the same area such as the passage 32 and the entrance zone 34. Further, the imaging device 20 may image an area at and/or behind the blocking element 30. This allows to determine whether a person 12 and/or movable object 14 have passed the blocking element 30. The imaging device 20 is in data-communication with the control device 22, e.g. via wires. The imaging device 20 may be attached to the first supporting device 26 and/or the second supporting device 28. Further, the imaging device 20 may be attached to a wall, a ceiling, and/or posts that are arranged in the vicinity of the blocking device 18.

[0114] In the embodiment of Fig. 1, the control device 22 includes a processor 36 and a memory 38. The processor 36 is in data communication with the memory 38, the blocking device 18, and/or the imaging device 20. This is indicated in Fig. 1 by the schematic wires which allows data communication between the respective components. The processor 36 and the memory 38 may be located within a housing of the second supporting device 28.

[0115] The processor 36 and the memory 38 are configured to execute various programs and/or algorithms. The processor 36 may be configured to control the imaging device 20 and the blocking device 18. The control device 22 may be configured to execute the method as described in connection with Fig. 5 (see below).

[0116] In the embodiment of Fig. 1, the interface device 24 is arranged in the first supporting device 26 and/or the second supporting device 28. The interface device 24 is also in data-communication with the control device 22. The interface device 24 is provided for recognising, obtaining, and/or detecting access requests by the per-

son 12 and/or the movable object 14. The access requests may be executed by inputting information into the interface device 24, paying an access fee, presenting a ticket, and/or presenting other types of access means which can be recognised/detected by the interface. Upon recognition of an access request, the interface device 24 generates an access request signal that is transmitted/forwarded to the control device 22. The access request signal may comprise any type of data that allows the determination that a particular access request is submitted to the interface device 24. For example, the access request signal may include information who and/or what has a valid access, the number of person(s) 12 and/or movable object(s) 14 that have a valid access, the type of person(s) 12 and/or movable object(s) 14 that have a valid access, the time of access, etc.

[0117] The interface device 24 may include a scanner for scanning a ticket, an input device for inputting an access request (such as a touchscreen, buttons, a keyboard), a payment device for accepting cash and/or card payment, and/or an antenna for detecting a token granting access. The interface device 24 may include reading devices for contactless reading of access authorizations, for example via a standard for wireless communication, such as RFID, NFC, WLAN, Bluetooth, BLE, UWB, and/or devices capturing biometric features, such as fingerprint scanners or cameras with facial recognition software.

[0118] The access control device 10 of Fig. 2 includes the same features, optional embodiments, and/or characteristics as the access control device 10 of Fig. 1 except for the following differences.

[0119] The blocking device 18 is dimensioned to allow access to a vehicle as an example of a movable object 14. The blocking element 30 may be a barrier that is rotatably supported by the first supporting element 26.

[0120] The access control device 10 of Fig. 3 includes the same features, optional embodiments, and/or characteristics as the access control device 10 of Fig. 1 except for the following differences.

[0121] The blocking device 18 further includes a second blocking element 40 which is movable supported by the second supporting device 28. The first blocking element 30 and the second blocking element 40 together restrict the access through the passage 32. Thus, if the first blocking element 30 and a second blocking element 40 are both in the closed position or state, the person 12 is prevented from passing the blocking device 18.

[0122] The control device 22 may be configured to generate an intermediate signal which can include an opening signal to the first blocking element 30 and a closing signal to the second blocking element 40. The intermediate signal may also include that both the first blocking element 30 and the second blocking element 40 are moved to an intermediate position which is between the open position and a closed position. In the intermediate position, the first blocking element 30 and the second blocking element 40 may define a partial access through

the passage 32.

[0123] The control device 22 may also be configured to generate a first closing signal to be sent to the first blocking element and a second closing signal to be sent to the second blocking element 40. This may be useful if a person 12 and/or a movable object 14 (e.g. a bicycle) - as schematically shown in Fig. 4 - pass blocking device 18. In this case, the person 12 usually passes the first blocking element 30 earlier so that the first blocking element 30 can be closed earlier, i.e. the first closing signal is generated before the second closing signal. The second closing signal is generated once the bicycle has passed the second blocking element 40.

[0124] A method for operating the access control device 10 for controlling the opening and closing of the blocking device 18 (for allowing access of the person 12 and/or the movable object 14 to the restricted area) is described in connection with the block diagram of Fig. 5.

[0125] In step 1, the imaging device 20 images the passage 32 and the entrance zone 34. For example, the imaging device 20 takes a video of the passage 32 and the entrance zone 34. The data generated by the imaging device 20 (data of the video) is forwarded to the control device 22.

[0126] In step 2, the control device 22 runs a program such as an artificial intelligence or a neural network for identifying a person 12 and/or a movable object 14 in the video. The identification of the person 12 and/or the movable object 14 can include a classification of the identified person 12 and/or movable object 14 in one or more types, such as an adult, children, a bicycle, a vehicle, and/or a trailer.

[0127] In step 3, the control device 22 places a virtual bounding box 42 around each identified person 12 and/or movable object 14. The shape and dimension of the bounding box 42 may be preset. Further, for each type of person 12 and/or movable object 14, a respective virtual bounding box 42 can be selected. As shown in Fig. 4, the person 12 and the movable object 14 are completely within the virtual bounding box 42. In other words, the virtual bounding box 42 indicates a volume a person 12 and/or a movable object 14 occupies in a given space. This is for example helpful for assessing when the blocking device 18 can be returned to the closed position: the closing signal is generated once the virtual bounding box 42 is outside the operational range of the first blocking element 30 and second blocking element 40. The bounding boxes 42 of the person 12 and bounding box 42 of the movable object 14 can form a group bounding box.

[0128] In step 4, the position of the virtual bounding box 42 is determined in a frame of the video stream. Subsequently, if there are a plurality of persons 12 and/or movable objects 14, the distance between the persons 12 and movable objects 14 is determined for example using a centre point of the respective bounding boxes 42. If a distance between any two of plurality of persons 12 and/or movable objects 14 is below a first threshold, these two persons 12 and/or movable objects 14 are con-

sidered to belong to a group. Further, it is checked whether the types of identified persons 12 and/or movable objects 14 belong to a predetermined combination of types that is stored in the memory 38. Such a predetermined combination may be an adult and a child or a person and a bicycle. If the identified persons 12 and/or movable objects 14 belong to such a predetermined combination, it is checked if a distance between them is below a third threshold. If so, the identified persons 12 and/or movable objects 14 are considered to belong to a group. The third threshold may be larger than the first threshold.

[0129] In step 5, steps 2 and 4 are repeated for each subsequent frame for tracking the movement of the person 12 and/or the movable objects 14. If a distance between any two of plurality of persons 12 and/or movable objects 14 is below a second threshold for a predetermined number of frames, these two persons 12 and/or movable objects 14 are considered to belong to a group. The second threshold may be larger than the first threshold.

[0130] In step 6, the interface device 24 sends an access request signal to the control device 22 if the person 12 and/or the movable object 14 presents a ticket or other forms of authentication to the interface device 24. The access request signal may include the number of each type that are allowed to pass the access control device 10. This information may be stored on the ticket. For example, a ticket allows access for 5 persons. The control device 22 then checks whether the group includes 5 persons 12 or less. If so, the control device 22 generates the opening signal or the intermediate signal depending on the number of persons 12 of the group. If not, i.e. 6 or more person 12 are identified with the group, the control device 22 generates the closing signal.

[0131] In step 7, the control device 22 predicts based on the prior movement of the persons 12 and/or movable objects 14 when the persons 12 and/or movable objects 14 reach the first blocking element 30 and/or the second blocking element 40. This may allow to open the blocking device 18 at the right point of time i.e. that the persons 12 and/or immovable objects 14 need not to stop at the blocking elements 30, 40.

[0132] In step 8, the control device 22 determines whether each person 12 and/or movable object 14 has passed the first blocking element 30 and the second blocking element 40. If so, the control device 22 generates the closing signal. Alternatively, the control device 22 generates a first closing signal to be sent to the first blocking element 30 if a person 12 and/or movable object 14 has passed first blocking element 30. Further, the control device 22 generates a second closing signal to be sent to the second blocking element 40 if a person 12 and/or movable object 14 has passed second blocking element 40. For example, the first blocking element 30 is closed earlier when a person 12 passes the first blocking element 30 compared to the closure of the second blocking element 40 through which a bicycle pass.

[0133] While the invention has been described in con-

junction with the exemplary embodiments described above, many equivalent modifications and variations will be apparent to those skilled in the art when given this disclosure. Accordingly, the exemplary embodiments of the invention set forth above are considered to be illustrative and not limiting. Various changes to the described embodiments may be made without departing from the spirit and scope of the invention.

Claims

1. An access control device for a person (12) and/or a movable object (14), comprising

a blocking device (18) configured to be, after receiving an opening signal, in an open state in which the person (12) and/or the movable object (14) can pass the blocking device (18) and to be, after receiving a closing signal, in a closed state in which the blocking device (18) blocks the person (12) and/or the movable object (14) from passing the blocking device (18),
 a control device (22) configured to generate the opening signal and/or the closing signal, the control device (22) being in data communication with the blocking device (18), and
 an imaging device (20) configured to image the blocking device (18) and a vicinity thereof, the imaging device (20) being in data communication with the control device (22),
 wherein the control device (22) is configured to identify the person (12) and/or the movable object (14) in the image generated by the imaging device (20), and
 wherein

the control device (22) is configured to generate the closing signal if the control device (22) has determined that the identified person (12) and/or movable object (14) has passed the blocking device (18) and/or the control device (22) is configured to generate the opening signal if the control device (22) has determined that the identified person (12) and/or movable object (14) is in front of the blocking device (18).

2. The access control device of claim 1, wherein

the open state includes that the blocking device (18) maintains to be in an open position, the blocking device (18) is configured to be manually opened by the person (12) and/or the movable object (14), or the blocking device (18) is moved to the open position, and/or
 the closed state includes that the blocking device (18) is locked to a closed position or that

the blocking device (18) is moved to the closed position.

3. The access control device of claims 1 or 2, wherein the imaging device (20) is further configured to image an entrance zone (34) in front of the blocking device (18),
 wherein the control device (22) is configured to track the movement of the identified person (12) and/or movable object (14) in the entrance zone (34) for determining when the opening signal is to be generated.

4. The access control device of any preceding claim, wherein the control device (22) is configured to place a virtual bounding box (42) around the identified person (12) and/or movable object (14), the bounding box (42) indicating dimensions of the identified person (12) and/or movable object (14), and
 wherein

the control device (22) is configured to generate the closing signal if the control device (22) has determined that the bounding box (42) has passed the blocking device (18), and/or
 the control device (22) is configured generate the opening signal if the control device (22) has determined that the bounding box (42) is in front of the blocking device (18).

5. The access control device of any preceding claim, wherein the control device (22) is configured to determine a group of person(s) (12) and/or movable object(s) (14) in the image generated by the imaging device (20) by determining a distance between the person(s) (12) and/or movable object(s) (14) in the image.

6. The access control device of claim 5 when depending on claim 4, wherein the control device (22) is configured to determine the distance by using the bounding boxes, optionally a centre point of the bounding boxes.

7. The access control device of claims 5 or 6, wherein the control device (22) is configured to determine that the person(s) (12) and/or movable object(s) (14) belong to a group if the distance is below a first threshold or if the distance is below a second threshold for a predetermined number of times.

8. The access control device of any preceding claim, wherein the control device (22) is configured to classify the identified person (12) and/or movable object (14) into one of a plurality of types.

9. The access control device of claim 8, wherein control device (22) includes a memory (38) configured to

store a plurality of combinations of different types, and

wherein the control device (22) is configured to determine that the person(s) (12) and/or movable object(s) (14) belong to a group if the distance is below a third threshold and if the respective types are equal to one of the stored combinations.

10. The access control device of claims 7 to 9, wherein the blocking device (18) is further configured to be, after receiving an intermediate signal, in an intermediate state which provides partial access, wherein the control device (22) is further configured to generate the opening signal or the intermediate signal depending on the number of group members and/or the type of the group members.
11. The access control device of any of the claims 7 to 10, wherein the blocking device (18) includes a first blocking element (30) and a second blocking element (40), the first blocking element (30) and the second blocking element (40) being positioned adjacent to each other for defining a common access and the first blocking element (30) and the second blocking element (40) being each configured to be, after receiving the open signal and/or the closing signal, in the open state and/or the closed state, respectively,

wherein the control device (22) is configured to control the first block element and the second blocking element (40) independently from each other, and

wherein the control device (22) is further configured to generate the opening signal for the first blocking element (30) and/or the second blocking element (40) depending on the number of group members and/or the type of the group members.
12. The access control device of claim 11, wherein the control device (22) is configured to generate a first closing signal to bring the first blocking element (30) in the closed state if the control device (22) has determined that a first identified person (12) or movable object (14) has passed the first blocking element (30) and/or to generate a second closing signal to bring the second blocking element (40) in the closed state if the control device (22) has determined that a second identified person (12) or movable object (14) has passed the second blocking element (40).
13. The access control device of any of the claims 8 to 12, further comprising an interface device (24) configured to generate an access request signal upon receiving an access request, the access request includes a number for each type permitted to pass the blocking device (18),

wherein the control device (22) is configured to determine the number of each type in a group after receiving the access request, and
wherein the control device (22) is further configured to generate the opening signal if the control device (22) has determined that number of types for each type determined by the control device (22) is smaller than or equal to the number of a respective type in the access request.

14. The access control device of any preceding claim, wherein the imaging device (20) includes plurality of cameras which image the same area from different viewpoints,

wherein the control device (22) is configured to, for each camera, identify the person (12) and/or the movable object (14) in the respective images, and
wherein the control device (22) merges the results of the identifications for the respective cameras.
15. A method for controlling the opening and/or closing of a blocking device (18), the blocking device (18) being configured to be in an open state in which a person (12) and/or a movable object (14) can pass the blocking device (18) and in a closed state in which the blocking device (18) blocks the person (12) and/or the movable object (14) from passing the blocking device (18), the method comprising the steps of

imaging the blocking device (18) and a vicinity thereof,
identifying the person (12) and/or the movable object (14) in the generated image, and
executing one or both of the following steps:

bringing the blocking device (18) to the closed state when the identified person (12) and/or movable object (14) has passed the blocking device (18) and/or
bringing the blocking device (18) to the open state when the identified person (12) and/or movable object (14) is in front of the blocking device (18).

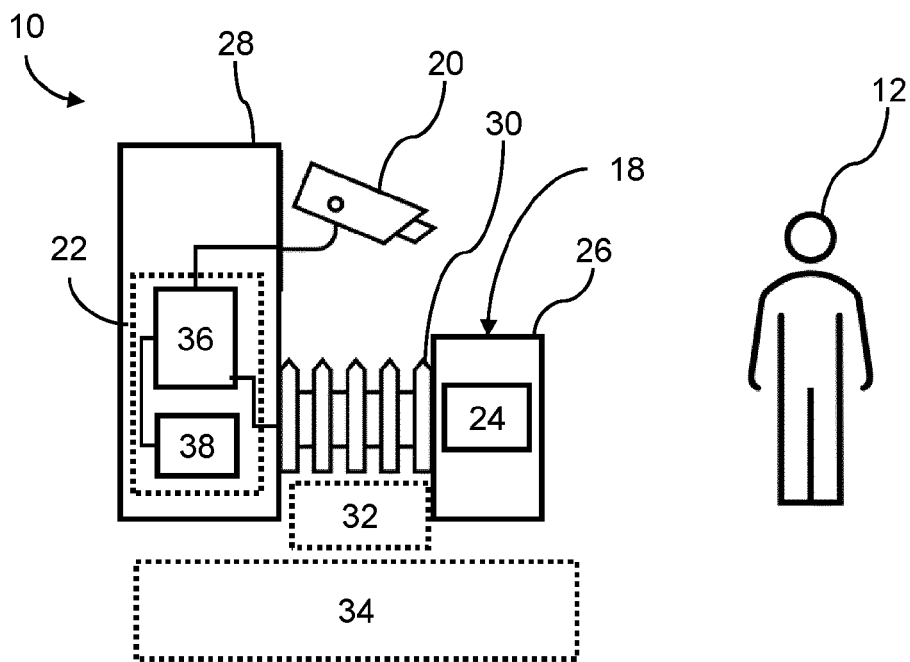


Fig. 1

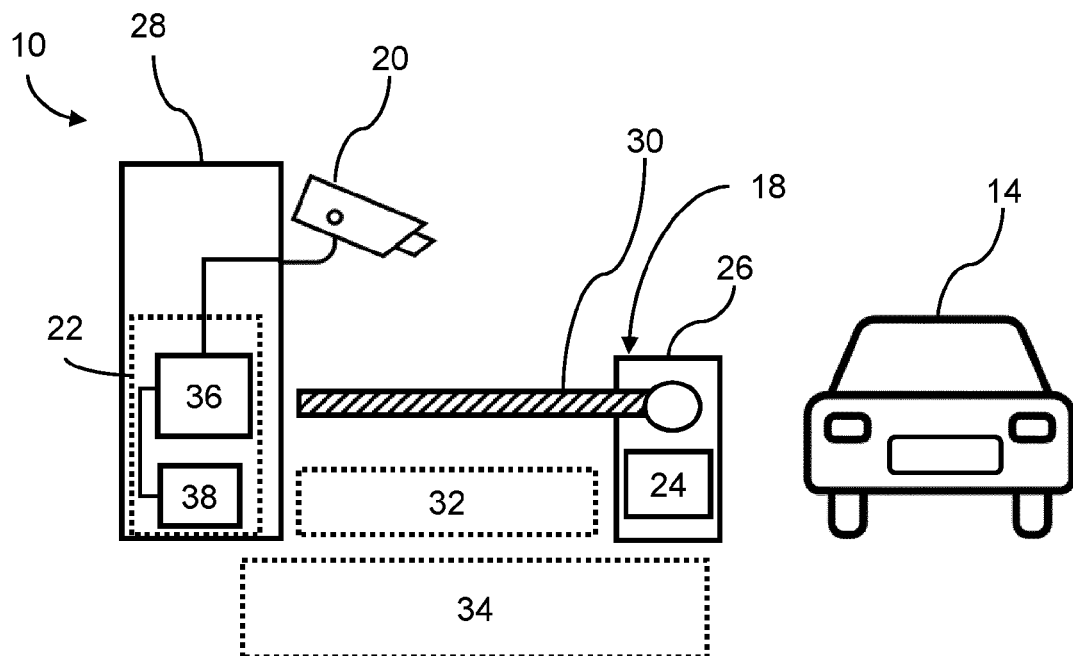


Fig. 2

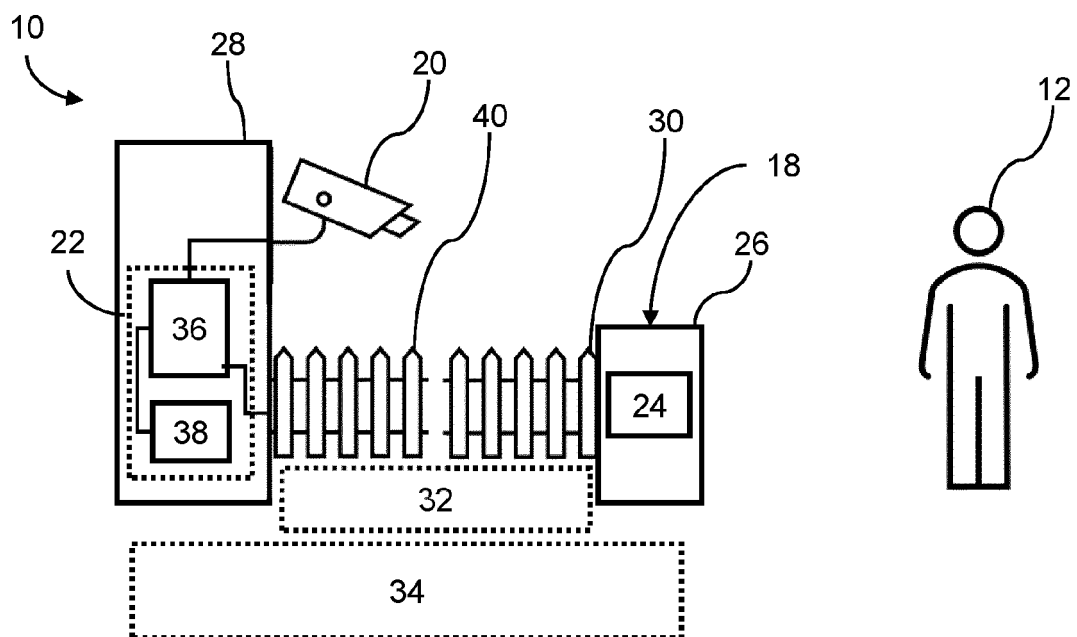


Fig. 3

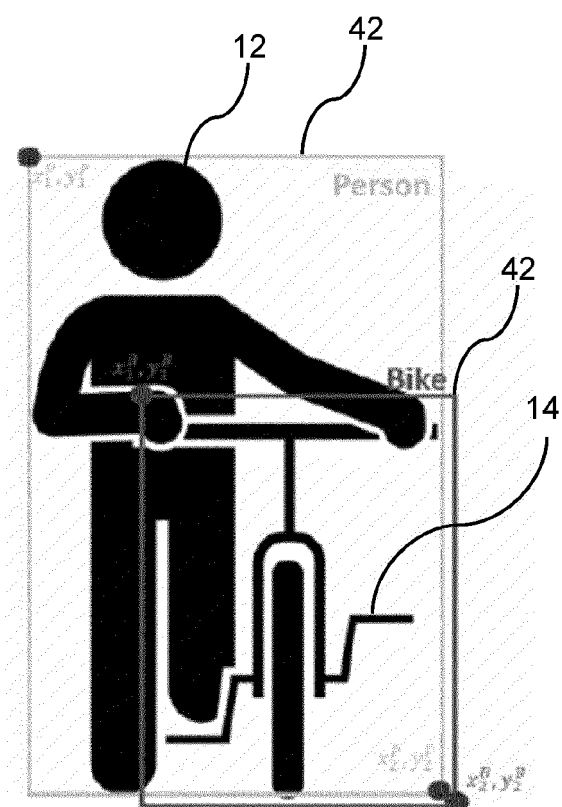


Fig. 4

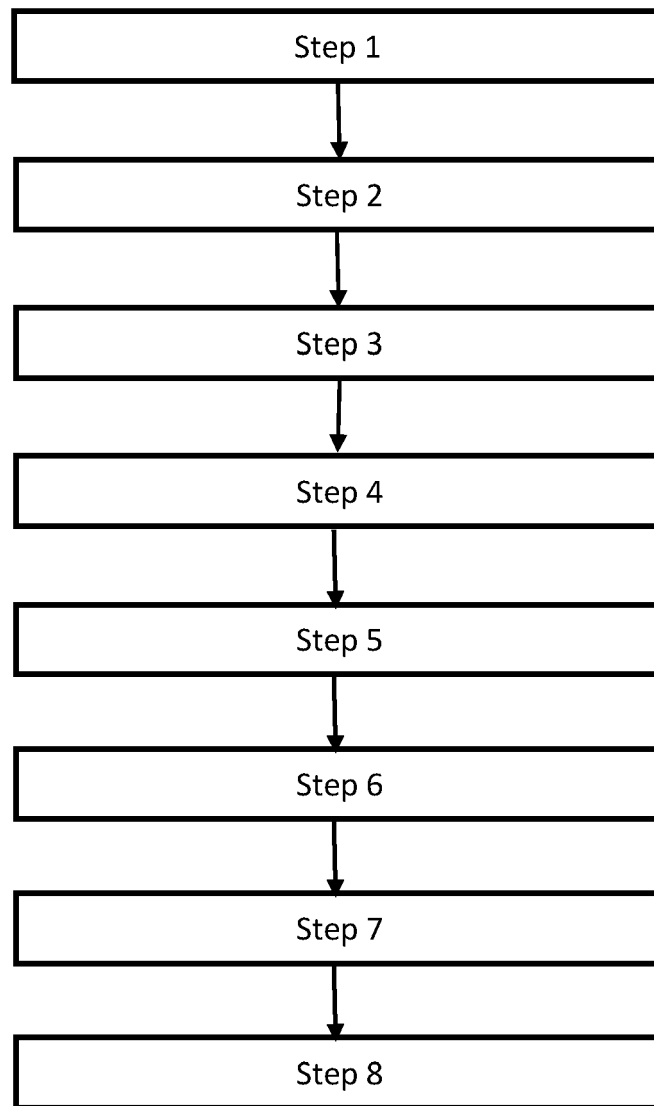


Fig. 5



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Application Number

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 25 July 2023	Examiner Neumann, Christoph
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