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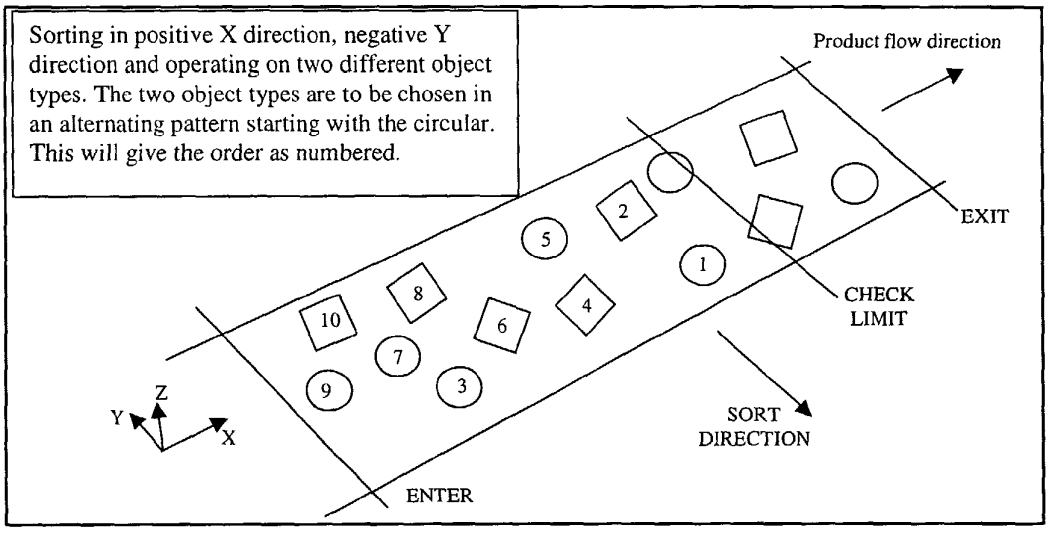
(54) **Title:** AUTOMATED PRODUCTION SYSTEM FOR OBJECT IDENTIFICATION, SELECTION AND TRANSPORT



(57) **Abstract:** System for selection and transport of an object out of a plurality of objects in an operation area comprising a system for detection of objects present in the operation area and an industrial robot including a manipulator and an operating system having a computer memory for storing information on the objects present in the operation area.

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Automated production system for object identification, selection and transport

TECHNICAL FIELD

The present invention relates to a production system including an industrial robot and a detecton system for localization of objects. More precisely the invention relates to a method and system including an industrial robot and a vision system for extracting an object out of a plurality of objects in a continuous production flow. With objects in this context should be understood both objects which are identical as well as object or groups of objects that are different in shape, color softness and such. The objects arrive into the robot working range in a continuous stream on a conveyor, a rotating plate or the like, or they arrive in layers of a pallet.

BACKGROUND OF THE INVENTION

It is known a system for sorting articles on a conveyor belt where the articles passes a detection area before entering a robot operation area. In the detection area the articles are identified by order of sort, position and orientation. This information is stored in a memory of the robot operating system. By this information the articles are picked, lifted and oriented by the robot and placed at a specified position in a reception area. A typical application of this system is picketing of chocolate pralines or cookies.

When working with heavier articles the picking process decreases due to acceleration forces. The risk of dropping the article also increases. When working with articles, which have an uneven or rough surface the technique of lifting with vacuum gripper become more difficult. A mechanical gripper is havier, more complcated and more expensive. A mechanical gripper is also less flexible.

From US 6,401936 a divert apparatus for a conveyor system is previously known. This is a sorting system for processing a disordered stream of items including three-dimensional non-flat articles. The apparatus regulates the flow of articles through the system by

singulating a disordered stream. There is also means for mechanically increasing the spacing between the items and a gate for discharging articles from the stream. The known system is designed for one type of articles only. When changing production the apparatus has to be re-adjusted.

Thus there is a need in the industry for flexible handling arbitrary articles in a continuous production flow.

SUMMARY OF THE INVENTION

In a first aspect of the invention there is provided a system for selection and transport of an object out of a plurality of objects moving in a product flow direction in an operation area, the system comprising:

a system for detecting the plurality of moving objects present in the operation area;

an operating system comprising a computer memory for storing information on the objects present in the operation area, means for defining a transport direction for each of the plurality of moving objects present in the operation area, wherein the transport direction is at an angle to the product flow direction, means for defining a passageway along the transport direction of each object, means for calculating the presence of other objects penetrating into each of said passageways, and means for selecting an object from said plurality of moving objects for which a passageway is free from penetration from any other moving object; and

an industrial robot comprising a manipulator operative to extract selected object from the plurality of objects in the operation area and move the extracted object in the transport direction.

In an embodiment, an algorithms is described for a selection of objects in a continuous production flow according to given sorting rules. A continuous production flow, which feeds objects into a robot working area is defined by the positive flow direction, hereafter named "X" and it's perpendicular direction in the horizontal plane of a right-hand coordinate system, named "Y".

In an embodiment, all objects information, such as position, orientation, type and size, are stored in a buffer in an industrial robot controller. A new object is requested from

the buffer when the robot is about to use the object as a target. The robot operation can only be performed when the object is within an entry and an exit limit of the X-direction. The robot controller supervises this. Within this work area it shall be possible to choose the object with respect to the priority rules in X-and Y-or/and Z-direction.

Preferred information for sorting:

- **Sort direction:**
  From which direction the sorting will be done. Given in object request command.
- **Safety distance:**
  The clearance area for sorting. Given in object request command.
- **Enter limit:**
  The limit where the robot can start operate on an object. Given when defining a new object buffer.
- **Exit limit:**
  The limit where the robot can't operate on an object. The objects will be erased from the buffer when they enter this limit. Given when defining a new object buffer.
- **Check limit:**
  Optional limit where the robot can't operate on the object. The objects will not be erased from the buffer when they enter this. Given in object request command.

The sorting algorithm chooses the object, which is the closest to the exit limit in X-direction and depending on the non-presence of other objects in direction of the sorting, the first object in the sort direction will be selected. A safety distance defines the required clearance area around an object. The algorithm will check both upwards and downwards the production flow for presence of other objects.

When a new object is requested from the object buffer, the sort direction and safety distance is given as parameters in the request command. The sorting algorithm will then choose which object the robot shall operate with.

By using a check limit, in the X-direction, as a parameter to the request command, it is

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possible to define the starting point from where the first object shall be extracted. The command will try to extract the first object between the check-and enter limit. This will have the effect that the sorting algorithm also takes all objects between the check limit and the exit limit into consideration when checking the safety distance for the nearest objects.

In an embodiment, the objects can be extracted from the flow without touching surrounding objects. The objects can be shuffled sideways without any risk of bumping into other objects in the production flow.

It is possible to combine the directional sorting with type request. The first object of a certain type in the production flow will then be selected according to previous described algorithm.

Normally the production flow is in the horizontal plane. However there is no limitation to what direction the production flows. As an example the production flow can be vertical. This situation arises when the products arrive into the operation area on a pallet where the articles are piled individually or in layers. The detection information is then achieved from package pattern or by having the pallet moved between the detecting area and the operation area.

In a second aspect of the invention there is provided a method of selecting an object out of a plurality of objects moving in a product flow direction in an operation area for transport to a predetermined location, the method comprising:

detecting the plurality of moving objects present in the operation area;

storing object and location information in a computer memory; and

selecting an object to be picked from the plurality of moving objects present in the operation area, wherein selecting the object comprises

defining a transport direction for each of the plurality of moving objects present in the operation area, wherein the transport direction is at an angle to the product flow direction,

defining a passageway along the transport direction of each of said plurality of objects,

calculating for each passageway the presence of penetration of any other of said plurality of objects into the respective passageway, and

selecting an object from said plurality of moving objects for which a passageway is free from penetration from any other moving object.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and advantages of the present invention will become more apparent to a person skilled in the art from the following detailed description in conjunction with the appended drawings in which:

FIG is an operation area with a plurality of objects for selection,

DETAILED DESCRIPTION OF THE INVENTION

The operating area in the embodiment showed in the fig is defined by the edges of a conveyor belt, a check limit line and a entry line. The transport direction is in the embodiment shown perpendicular to the flow direction. Normally a flow of products for picking arrive into a detection area (not shown) before entering the operation area. In the detection area all information of the articles are defined. This information contain type of article, size, position, orientation and other desirable information. At a predetermined time calculated from the flow speed and the distance between the detection area and the operation area the articles arrive into the operation area.

During this time the system calculated the transport direction for each of the articles to a predetermined position when the articles have reached the operation area. Before reaching the operation area the system also determine a passageway for each of the articles, along which the article must be transported. The passageway can be seen as a tunnel. Prior to arrival into the operation area the system also determine if any of the other objects present penetrates these tunnels. Thus each of those articles which has a clear tunnel can be chosen. An optimation program, having information on the speed of the flow, the performance of the manipulator and other information then chooses the optimal article for transport.

In an embodiment of the invention the detection system is a vision system. By a camera or a plurality of cameras the position and orientation information is achieved for each

article.

All such information is stored in a computer memory. The vision system gets continuous information of the articles passing the detection area. Thus the same article may appear on a plurality of detection areas that are overlapping each other. This results in the operating area being adjusted and thus always contain actual information.

The information received in the detection area may be used to direct a plurality of manipulators along the conveyor line. In a vision system that detect the articles prior to arrival into the operation area it is essential that the articles remaining on the conveyor remains at the same position and in the same orientation. This means that when an article is picked up or shuffled sideways the remaining articles must not be moved or even torched. If one of the articles are moved in one robot station its position will not be recognized in the next station.

The invention is not be limited by the embodiments presented above. Thus the production flow can be circular, as when the articles are placed on a rotating plate. The conveyor can also be continuous, such that the articles are passing several times through the detection area. The predetermined target position can be on either side of the conveyor belt and there can be a plurality of target locations at the same operation area.

The following problems are addressed by one or more embodiments of this invention:

- Shuffling objects off a conveyor without touching surrounding objects.
- Optimize production cycle performance by choosing products with shortest displacements.
- Sorted 3D picking of objects in order of their vertical positions. This can be used for efficient palletizing and de-palletizing while preserving the layers without the need for predefined layer schemes.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

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CLAIMS

1. A system for selection and transport of an object out of a plurality of objects moving in a product flow direction in an operation area, the system comprising:

a system for detecting the plurality of moving objects present in the operation area;

an operating system comprising a computer memory for storing information on the objects present in the operation area, means for defining a transport direction for each of the plurality of moving objects present in the operation area, wherein the transport direction is at an angle to the product flow direction, means for defining a passageway along the transport direction of each object, means for calculating the presence of other objects penetrating into each of said passageways, and means for selecting an object from said plurality of moving objects for which a passageway is free from penetration from any other moving object; and

an industrial robot comprising a manipulator operative to extract selected object from the plurality of objects in the operation area and move the extracted object in the transport direction.

2. The system according to claim 1, wherein the operating system further comprises means for selecting a certain type of object from among the plurality of objects.

3. The system according to claim 1, wherein the system for detecting objects comprises a vision system.

4. A method of selecting an object out of a plurality of objects moving in a product flow direction in an operation area for transport to a predetermined location, the method comprising:

detecting the plurality of moving objects present in the operation area;

storing object and location information in a computer memory; and

selecting an object to be picked from the plurality of moving objects present in the operation area, wherein selecting the object comprises:

defining a transport direction for each of the plurality of moving objects present in the operation area, wherein the transport direction is at an angle to the product flow direction,

defining a passageway along the transport direction of each of said plurality of objects,

calculating for each passageway the presence of penetration of any other of said plurality of objects into the respective passageway, and

selecting an object from said plurality of moving objects for which a passageway is free from penetration from any other moving object.

5. The method according to claim 4, further comprising:

picking the selected object; and

moving the selected object along the passageway that is free from penetration from any other moving object, for transport to the predetermined location.

6. The method according to claim 5, wherein the transport direction is perpendicular to the product flow direction.

7. The method according to claim 4, wherein the objects are moved along a product flow direction in the horizontal plane.

8. The method according to claim 7, wherein the product flow direction is circular.

9. The method according to claim 4, wherein the objects are moved along a vertical product flow direction.

10. The method according to claim 4, further comprising:

determining information regarding the objects, the information comprising size, position, speed, or orientation.

11. The method according to claim 5, wherein the object is picked without disturbing other objects in the operation area.

12. The method according to claim 4, wherein selecting the object further comprises selecting an optimal object based upon speed of the objects.

13. The method according to claim 4, further comprising:

repeatedly moving the objects in the product flow direction through the

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operation area.

14. A system as claimed in any one of claims 1 to 3, and substantially as herein described with reference to the accompanying drawings.

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15. A method as claimed in any one of claims 4 to 13, and substantially as herein described with reference to the accompanying drawings.

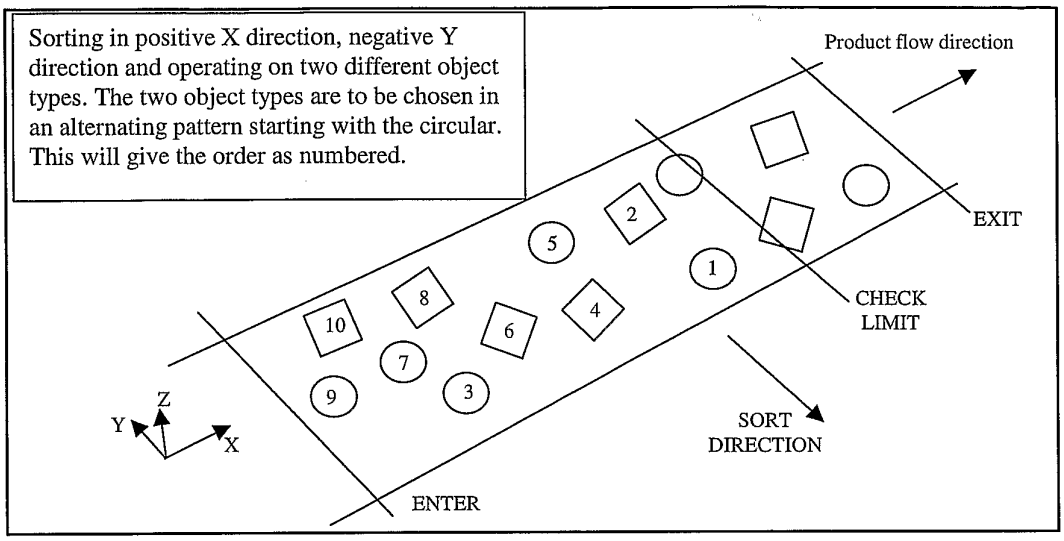
Sorting in positive X direction, negative Y direction and operating on two different object types. The two object types are to be chosen in an alternating pattern starting with the circular. This will give the order as numbered.
Product flow direction
EXIT
CHECK LIMIT
SORT DIRECTION
ENTER
Z
Y
X
1
2
3
4
5
6
7
8
9
10

Fig. 1