Flexible System for Recognition and Handling of Textile Articles

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ABSTRACT

The paper deals with the development and implementation of a flexible handling system which is dedicated to pick up textile articles of various shapes, weights and colours with arbitrary position and orientation. The articles are packed in transparent polyethylene bags and may be arranged in an ordered, partially ordered or completely unordered manner in a cardbox.

In a first step, the positions of the articles are recognized from upside to determine possible gripping points for the handling device. We perform this task with an image processing system in connection with a special lightening arrangement.

In a next step, a manipulator with a multiple pneumatic gripper - a special construction for this task - is properly placed into the box to fetch a selected textile article.

Additional sensory devices are applied to supervise the success of the gripping procedure and to repeat it in case of neccessity. Special algorithms are developed to completely empty the box without any a priori knowledge about the number of articles in the box.
In a first laboratory setup, a commercial six-axis industrial robot was used to perform the handling movements in order to test the equipment and algorithms. Now, a fast, light-weight and less expensive handling device is under development, which will replace the robot in the industrial application.

1 PROBLEM DESCRIPTION

The task we solved at the IFF deals with the problem of separation of packed articles in cardboxes, also known as "gripping into the box". There are three main problems to be solved:

- measurement of suitable characteristics for recognition and separation of the articles
- execution of the gripping procedure by using the measured characteristics
- success check of the gripping procedure and - if necessary - repetition of the first two steps.

Following boundary conditions were given:

- The articles, which are to separate, are arranged in an ordered manner in a cardbox.
- The dimensions of the cardboxes (lenght, width, height) are known.
- The articles are packed in polyethylene bags. Each of the foil bags represents an element to identify and to separate.
- The number of articles per cardbox is nominally known. Caused by packing errors they can include more or less articles. The system has to identify the empty state of the cardbox.
- The system possesses information about the weight and the approximate dimensions of the articles. Caused by different packing schemes (for example, folding up) the dimension information is not reliable. The weight is variable due to different kinds of textile materials. We assume a maximum variation of +/- 25% of the nominal weight.
- The information about the packing pattern is formally known and at disposal, but also not reliable, due to packing variations.
- It is assumed that all articles in a box are identical.
- The articles have to be picked up from the top. Hence, the upper side of the cardboxes must be removed .

The packing schemes of the textile articles in the cardboxes are subdivided into following patterns:

- articles are ordered and upright standing,
- articles are ordered and lying,
- articles are unordered.

In a first step, the investigations were restricted to ordered (standing and lying) packing patterns.

Each of the regarded packing pattern can be subdivided into a number of possible arrangements of the articles within the cardbox. This subdivision of the packing patterns is denoted as packing structure. The packing structures, which are relevant to the customer, are shown in Fig. 1.

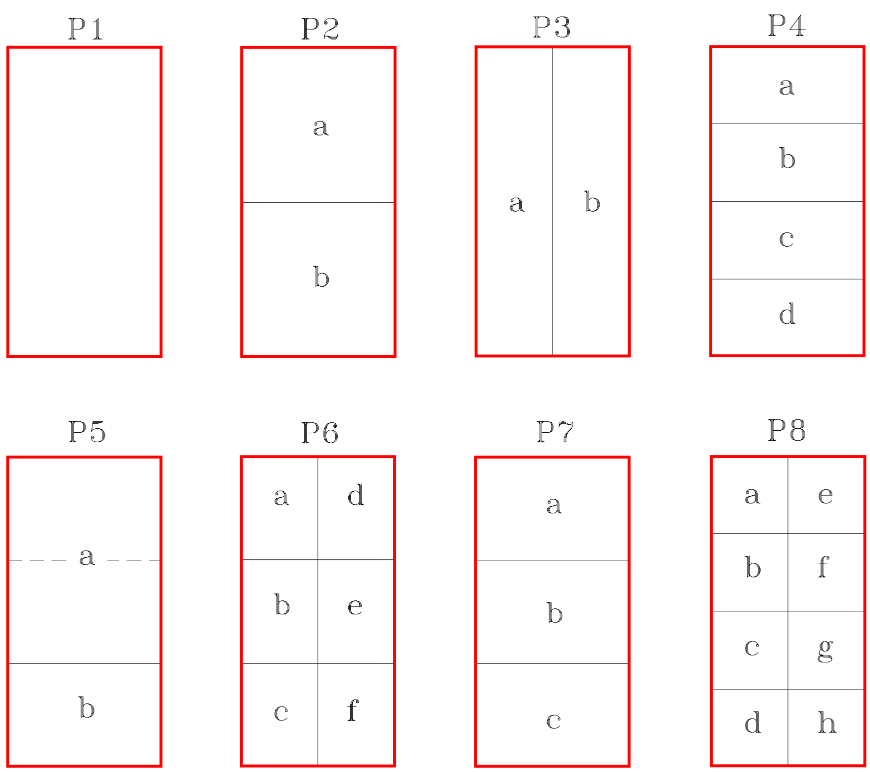


Figure 1. Packing structures

2 RECOGNITION SYSTEM

2.1 Target Functions for the Recognition System

The device must be equipped with sensors, which have to perform the following tasks:

- recognition whether the cardbox is empty or not,
- selection of the appropriate evaluation process,
- determination of gripping points,
- selection of the gripper,
- verification of the number of gripped articles .

2.2 Relation between Article Characteristics and Recognition Target

The relationship between target function, characteristics and recognition assembled in Table 1 shows that the a priori information about the features can only be used for the verification function. On the other hand the recognition of the packing structure has a large importance, because this characteristic is the basis for the further course of events (recognition, gripping). Alternatives for this characteristic are not available. A recognition of the packing structure is possible on the basis of following article features:

- optical features,
- dielectric features,
- behaviour at sound waves.

Since the dimensions of the cardboxes are known the measurement windows for part recognition can be adapted to optimize time and precision of the recognition process.

Table 1: Relationship between Target Functions and Characteristics

target	characteristics	detection
Check of empty state	number	measurement, comparision with a priori information
	net height of the articles in the cardbox	measurement
determination of the gripping point	largest area	measurement
	highest point in the card-box	measurement
selection of the gripper	packing structure	measurement
	weight, size	measurement, comparsion with a priori information
selection of the evaluation process	packing structure	measurement
verification of the number of gripped articles	weight	measurement, comparision with a priori information

According to the part and process characteristics several geometrical, optical and other physical detection methods were tested.
As a result, the light-stripe method has been proved to be suitable for the solution of the complex recognition task.

2.3 The Light-Stripe Method

2.3.1 Principle of working. If a light beam goes through a lens of half-cylindrical shape, a light line will be projected. In the direction of this line it is possible to detect a height profile. The light beam produces quasi a section through an object. Therefore this approach is called light-section procedure.

The mathematical basis for height measurement is the triangulation technique. It is a relative measurement process and therefore it is necessary to calibrate the system one times.

2.3.2 Measurement system configuration. Following terms of dimensions of the cardboxes are introduced: cardbox width, cardbox depth and cardbox height.

Due to the possible packing structures in the cardboxes it is necessary to use at least eight light lines. In direction of cardbox width two lines are projected. The projection of six lines is necessary in direction of cardbox depth.
By this way, the cardbox is divided into 8 measurement windows. Fig. 4 explains the configuration of the measurement windows.

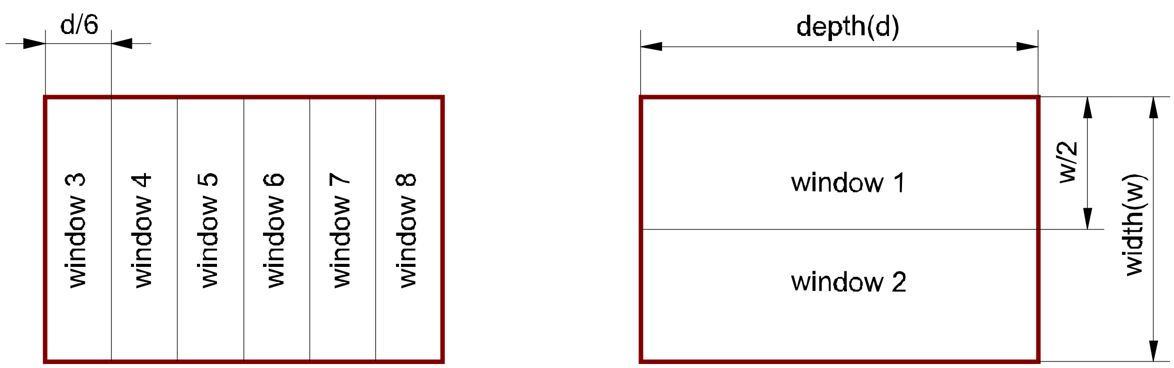
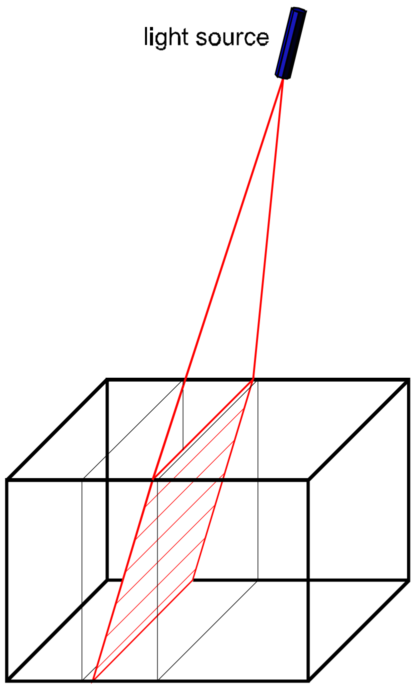


Figure 4. Configuration of the measurement windows

Each light line is projected parallel to the largest edge of the window in one of the 8 measurement windows.
The measurement window has a specified volume in dependence of the cardbox height. The line changes its position in the measurement volume corresponding to the height of articles in the cardbox. The angle of incidence of the light line is specified by the maximum cardbox height, because the light line have to remain within the measurement volume from bottom to top of the box (Fig. 5).
Each light line is produced by a diode laser with a cylindrical lense. The projected line pattern is recorded with a CCD-camera and analyzed with a image processing computer. Fig. 6 show the measurement arrangement.

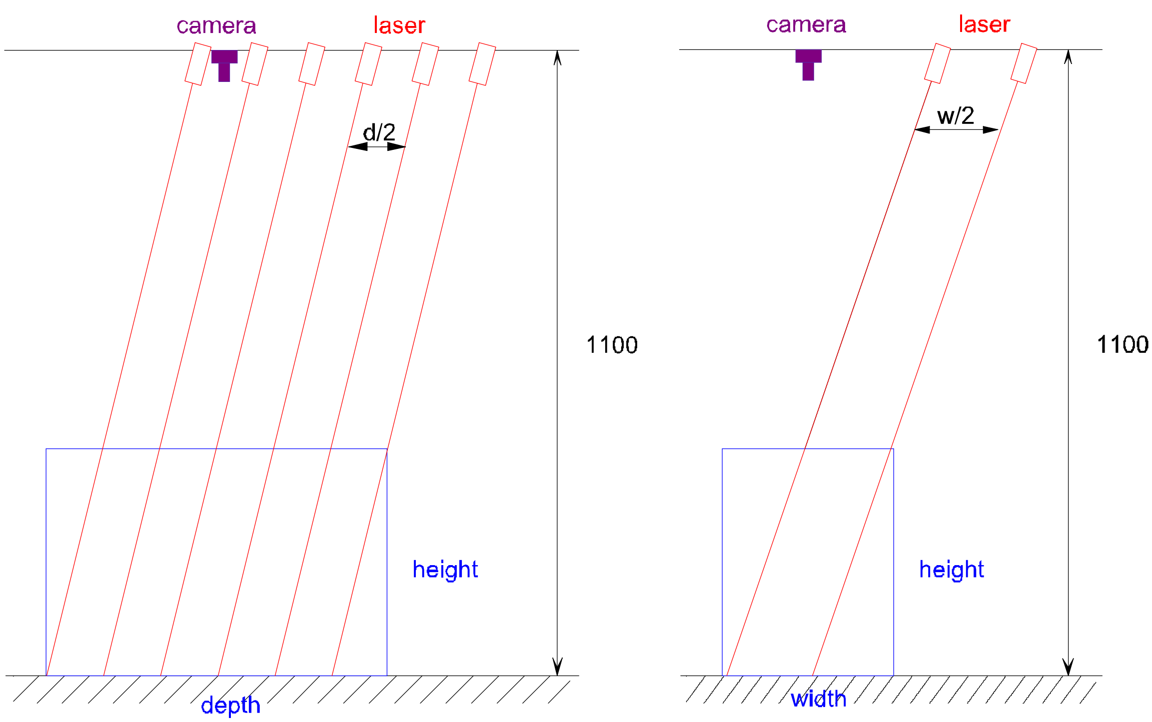


The laser and camera systems are mounted in a height of approximately 1100 mm above the cardbox bottom.

A complete recognition of packing structures for all cardboxes is possible with the configuration of measurement corresponding to Fig. 6.

Figure 5. Projected light lines in a measurement window

Figure 6. Configuration of the packing pattern recognition system



mesurement arrangement (side view)

mesurement arrangement (front view)

3 GRIPPING SYSTEM

3.1 Principle of Working

Preliminary experiments to grip textile articles have shown that it is possible to grip all articles with pneumatic grippers and a powerful vacuum. Therefore, a vacuum gripper principle was selected and a constructional optimization was carried out.

3.2 Gripper Construction

Fig. 7 shows the construction of our gripper.

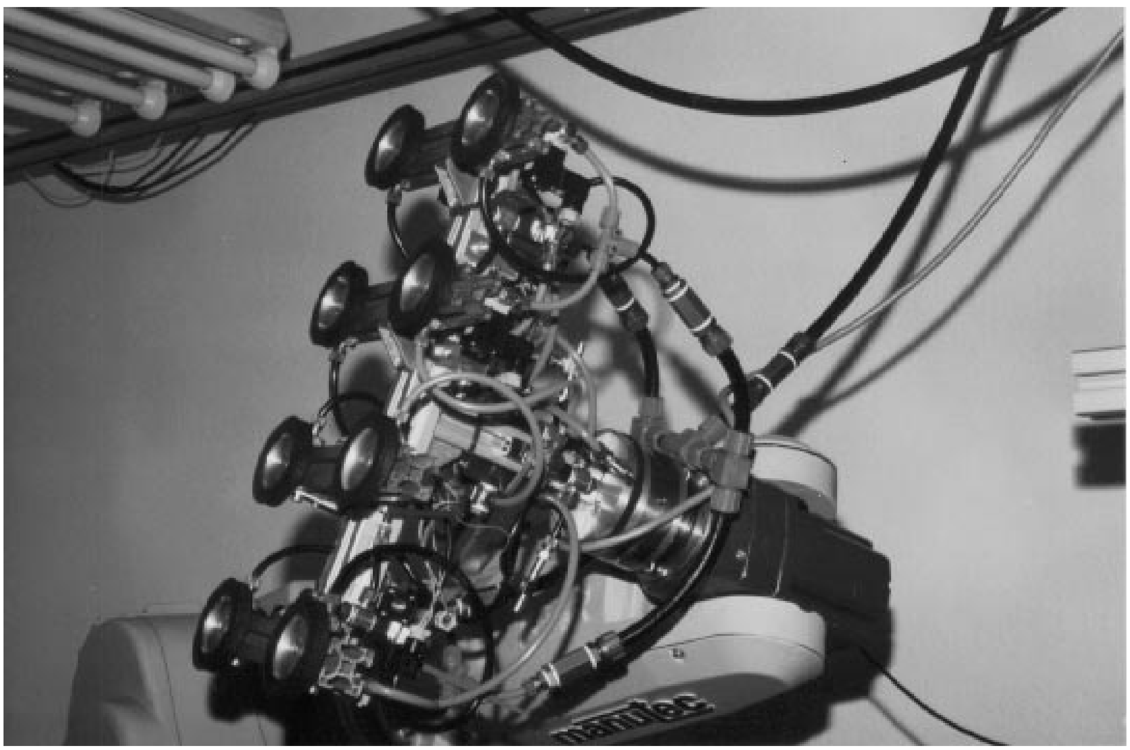


Figure 7. Gripping system

The gripper consists of an aluminium chassis, which carries eight movable pneumatic elements. Each element can be controlled separately. The dimensions of the

chassis and the gripping elements as well as their spatial arrangement were experimentally optimized in order to handle all possible cardbox sizes.
The gripping element is a very flat aluminium cylinder equipped with a switchable Ventury nozzle for separate vacuum generation. To avoid sucking marks due to strong retraction of the polyethylene foil there is a sieve inside the cylinder. The working border of the gripping element is equipped with a particularly shaped rubber lip.
Therefore, a reliable sealing is achieved even under high accelerations. Experiments have shown a safe gripping and holding behaviour on accelerations up to 2 g in either direction.

4 EXPERIMENTS

In a laboratory setup, a Siemens robot Manutec r15, with a payload of 15 kg is used as a manipulator. Force-torque-sensors for the requirements of the experiments are commercially available.
For the recognition of packing structures with help of the light-stripe method the following components are used: a diode laser for projection of light lines and an image processing system for recognition and processing of them.
The diode laser emits visible light with a wavelength of 670 nm and an output power of 10 mW. The spot light of the diode laser is modified to a line by a cylindrical lens. In this configuration, the laser meets the requirements of the laser safety class II according to DIN 58 126. Consequently, special safety means for eye protection are not necessary.
The lines, which are projected into the cardbox, are recorded by a black and white CCD-camera. An image processing computer analyzes the image and determines the gripping point.

For a whole picking cycle (i.e. recognition, pick and place), an overall time of less than 10 seconds is necessary. While the image processing procedure takes only about 1 sec., major part of time is required for the handling process.

In Fig. 8, the configuration of the experimental system in the laboratory of the IFF is shown.

Figure 8. Experimental system

5 SYSTEM LIMITS

5.1 Recognition System

The height resolution of the light-stripe method depends on the angle of incidence of the light source and of the image size of the camera. The angle of incidence of the line diode lasers is determined by the size of the measurement windows and the maximal height of the cardboxes. It is approximately 63.4 degrees relative to the cardbox bottom. The recorded image size of the camera is determined by the width and depth of the cardbox, too. With this conditions the height resolution is approximately 5 mm. By use of 2 cameras the height resolution can be doubled.

In practice, due to reflections on the foil, the smallest measurable height displacement is slightly larger.
Because of the limited light power of the diode laser, the ambient light has a decisive influence on the behaviour of the recognition system. An absolute prevention from ambient light is not necessary. Nevertheless, a direct illumination of the cardbox by artificial light sources should be avoided.

5.2 Gripping System

Experiments with the gripping elements showed, that a careful handling of the complete range of articles can be achieved with large holding forces, using only one multiple gripper with separately controllable gripping elements. Furthermore, handling experiments under high accelerations showed, that a gripping at the margin of articles can cause a drop off. This means, that an exact determination of the gripping point in the centre of the gripping area of articles has to be guaranteed the recognition system.
Using our developed algorithms for determination of position these requirements are met and they guarantee a reliable handling of articles.

6 FURTHER WORKS

Further works on the handling system have to deal with the development of a prototype. The fundamental technological processes and the boundary conditions are defined but we have to collect experiences in the continuous operation mode as well as in exceptional situations.
In a further step a prototype will be built and tested to perform an optimization of all components.