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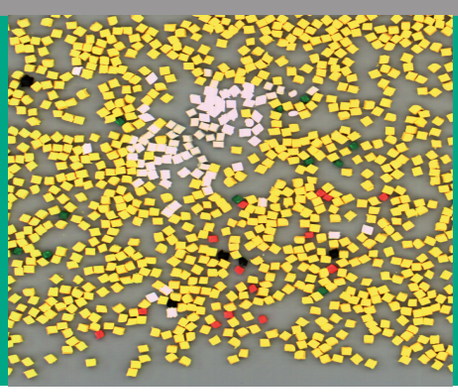

Automatic Sorting of Bulk Material

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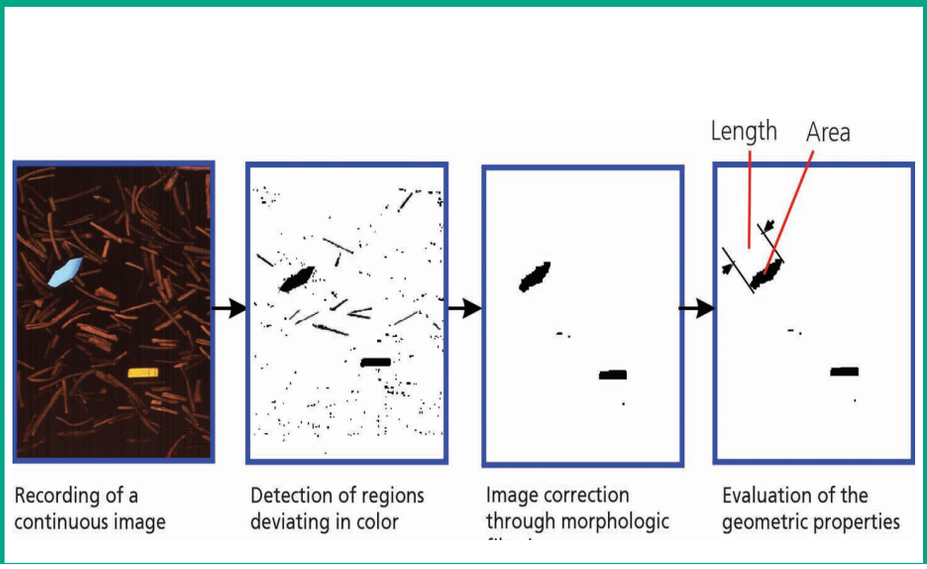
Task Definition

Bulk material consists of loose particles to be conveyed, e.g. ore, pellets, or cereals. An essential factor for industrial processing of bulk material is the purity of the relevant product. At least foreign objects must be sorted out, and in some cases even defective particles. Obviously the sorting criteria directly depend on the product to be sorted. The images above represent three examples for industrial sorting tasks: plastic granulates, stems of tobacco leaves, and minerals.

The purity of color, e.g., is a mandatory requirement in the production of plastic granulate. Objects with a deviating color must be expelled, regardless of their size and the type of color deviation. Even more important is the sorting of plastic pellets for recycling.

In the scope of cigarette production, the tobacco is checked for foreign bodies which must be sorted out, e.g. scraps of plastic, rubber and string. Other than the plastic granulate, tobacco does not have a pure color, but covers a variety of color values which could also belong to foreign particles. To cope with this, in addition to color inspection, it is necessary to check the suspicious objects in their geometric properties.

The image with the minerals shows a sorting task in which the objects must be checked from both sides. Furthermore, in this example the area ratio of good and undesired material has to be detected and assessed.



Solution

For the automatic sorting procedure, a thin layer of the bulk material is spread on a conveyor belt which is running, e.g., at 3 m/s. At the end of the transport line, the product leaves the belt and flies following a parabolic course. A color line-scan camera is positioned immediately after the transport line. It records a continuous image of the flying bulk material.
An appliance with adapted color and brightness provides for the appropriate background illumination. A series of air jets is arranged in a row perpendicular to the material flow and approx. 20 cm downstream from the camera's line of sight. These jets blow defective particles out of the material stream. The spacing between the jets is, e.g. 5 mm, which makes 200 jets per meter of belt width. During the flight time of approx. 70 ms, between the camera's line of sight and the row of jets, a high-speed vision system identifies defective objects in the mass stream. This vision system calculates position and time information for the jets to expel only the defective objects and a minimum amount of accepted material.

The Figure above represents the principle of the inspection procedure for automatic detection of foreign objects in tobacco: the first step of image processing is a color classification for every pixel. This results in a set of binary images which indicate all those pixels with an uncommon color for tobacco. The next step is a filter procedure where single pixels and small objects are removed from the binary images. Finally the remaining objects are classified based on geometrical features.

System Specifications

Sensor: Color line-scan camera with 2048 pixels

Illumination: Fluorescent tubes

Vision system: PC under Windows with two special plug-in boards for image preprocessing

Throughput: 20 Mio. pixels/s

Expeller: jets with magnetic valves, spacing 5 mm

Learning procedure (system operation): in applications such as tobacco and granulates, the system learns automatically; no user interaction is required for teaching.

Performance (for tobacco stems):
Conveyor belt width: 90 cm
Transportation speed: 3 m/s
Mass flow: 2.5 t/h

Detection rate: approx. 95% (relative to a set of defects defined by the user)