of marking is a convenient and concise representation of the specific and basic data about the product.


Figure 1: Product with alphanumeric marking


Figure 2: Product with Data Matrix code

Based on the general formulation of the problem, the following subtasks can be distinguished, which must be solved by the system:

1) detection and recognition of the type of marking;
2) marking recognition;
3) identifying possible marking problems.

In general, the following requirements can be imposed on the system that will solve the assigned tasks:

- **High speed of work.** The production line is moving very quickly, so the detection of defects should be carried out with minimal delays;
- **Autonomy.** The system should minimize operator involvement in the quality control process;
- **Universality.** The system should be configured to recognize the marking of any product;
- **Adaptability.** The system must work under any conditions that occur in production (for example, insufficient lighting, personnel errors, etc.).

Let's list the main problems with marking [2]:

1) **lack of ink:** in case of receipt of products on the production line without marking, the system must conclude that there is no ink;
2) **camera shift:** if no data on the recognition results are received from the neural network modules, but the system knows that movement along the production line has begun, then it must conclude that the camera has shifted;
3) **bad marking:** marking was found and recognized, but did not match the template representation. In this case, the system must conclude that the marking is incorrect;
4) **unreadable marking:** if the marking is blurry and cannot be recognized, it is necessary to stop the production line and report the error to the operator.

For problems 1,3 and 4, it is necessary to screen out products that have a problem marking. The occurrence of these problems implies a complete stop of the production line movement and reporting to the operator about the problem.

## III. OVERVIEW OF EXISTING APPROACHES

Despite the existing interest in the autonomy of production processes and the indisputable advantages that its implementation entails, tasks similar to those described are solved in a large number of cases with the participation of a person. The operator simply checks a part of the production periodically and randomly. This approach has disadvantages:

- only a small part of the production passes inspection, so there is a possibility that the defective marking will be missed;
- the speed of a person's reaction to an emergency situation may be insufficient;
- a person may not notice a small difference between the checked marking and the template one;
- the manual verification work is monotonous.

Existing projects are based on hardware solutions, for example, on the use of special sensors [4].

Such solutions implement marking recognition, but have a number of important disadvantages:

- Unstable recognition quality, depending on the conditions under which the recognition is performed. Since the production line moves quickly, the necessary conditions for high-quality recognition are often not met;
- Necessity to purchase specialized software to configure sensors.

Thus, such solutions create additional difficulties in operation, which are manifested in the need, in addition to selective manual control of product quality, to control the recognition system itself.

## IV. PROPOSED APPROACH

The proposed approach is to use a pipeline structure of separate neural network modules, each of which solves its own subproblem of marking recognition. The task of this pipeline is to detect the marking, determine its type and recognize it. Let us stop on the system architecture in more detail.