# DESIGNING AND IMPLEMENTING AN EXPERIMENTAL MODEL OF A SYSTEM FOR INVENTORYING CUTTING TOOLS

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*ABSTRACT: The development of an automated system for real-time inventorying of cutting tools in a workshop using image processing technology is proposed. When the tool is placed on the shelf by the operator, its position and weight are calculated based on data measured by a series of load cells arranged under the platform. The newly recorded positions are verified by a mobile camera with 2-axis translation driven by two stepper motors. The captured images of the cutting tools are analyzed by an image recognition algorithm that classifies them based on shape and size. This information is then stored in a central database, which can be quickly and easily accessed to check available stock and place new orders.*

*KEYWORDS: Cutting tools, image processing, automation*

## 1. Introduction

The main objective of designing and implementing the experimental model [1] is to create a fully automated and modular inventorying system that can be easily integrated with other factory management systems such as production planning or quality management. This system aims to reduce the time and eliminate the cost of manual inventorying by human resources. (Fig 1)

Furthermore, it can contribute to improving efficiency and productivity by reducing waiting time for required tools and ensuring their constant availability.

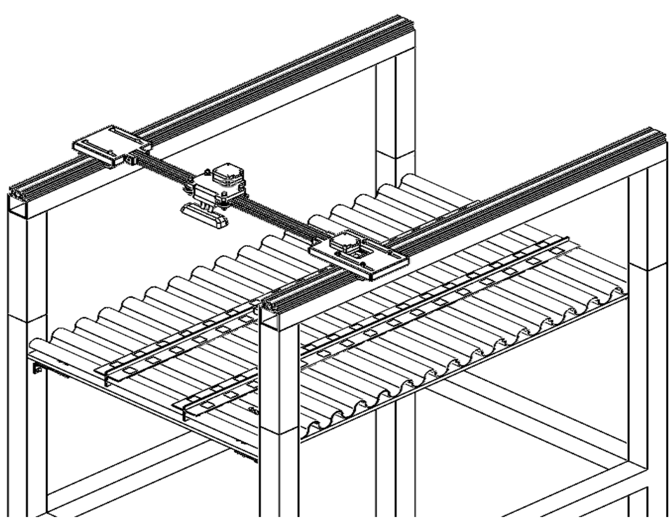

Fig 1. Model 3D Sistem

## 2. Working principle

### 2.1 System logic diagram

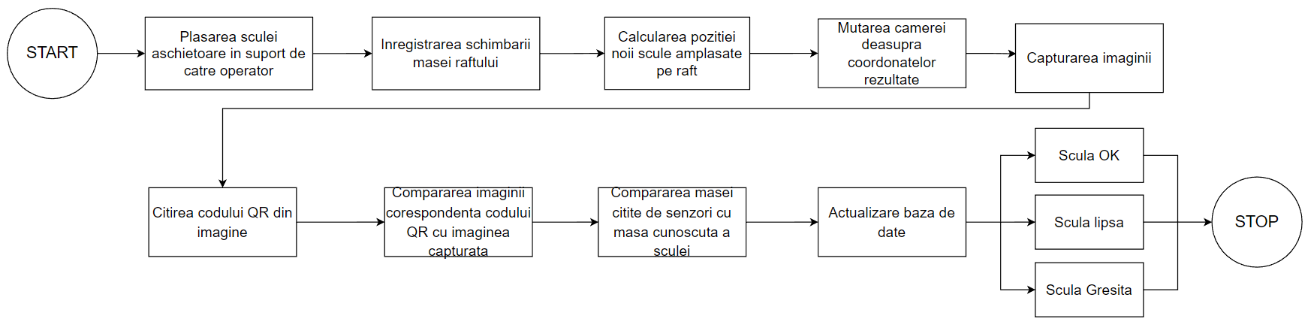


Fig 2. Logic diagram

### 2.2 Sensors operating mode

To constantly measure the mass of the shelf and calculate the positions of the tools placed on the shelf, four 20-kilogram load cells with HX711 Amplifier are used, positioned at each corner of the shelf (Fig 3). Since the sensors are located at the corners, each of them will measure different mass values, which can be used to calculate the center of gravity of the shelf. By knowing the previous center of gravity, current center of gravity, previous mass, and current mass, we can approximate the position of the object placed on the shelf.

The calibration of the flatness of the shelf is done manually using a screw and a nut.

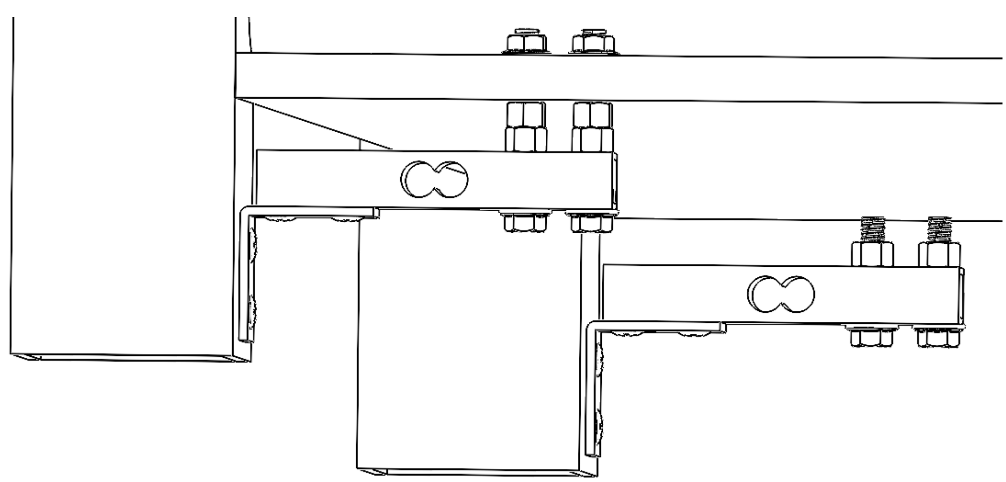

Fig 3. Load cell assembly.

### 2.3 The operation mode of the camera positioning system.

The mobile camera has two translational movements on the X and Y axes. The movement is achieved and controlled by two stepper motors. The modularity component of the system is provided by the movement on the X-axis on the rack and pinion mechanism (Fig 4). Once two or more shelves have been fixed, the mobile carriage can easily move to the next rail and rack. The other carriage on the X-axis serves as a guide.

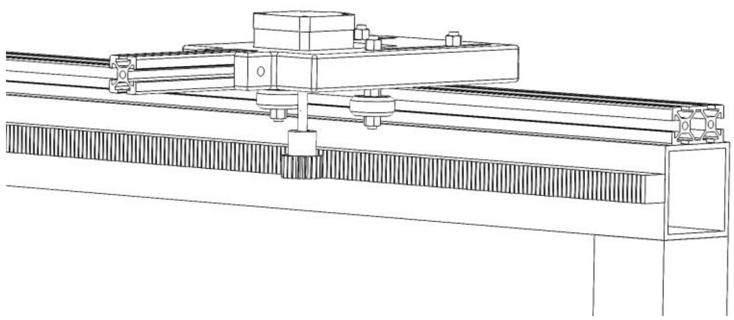

Fig 4. Rack and pinion assembly.

Since over time, the rack may separate the shelves due to the force applied by the pinion, it is necessary to modify it for additional and better fixation (Fig 5):

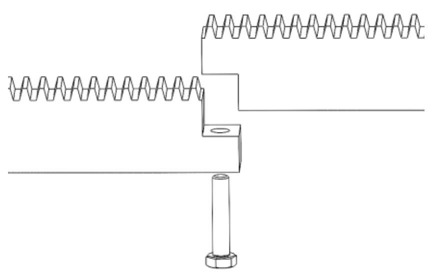

Fig 5. Rack assembly

Since the carriage's travel distance on the Y-axis is known, a fixed belt system can be used at both ends (Fig 6).

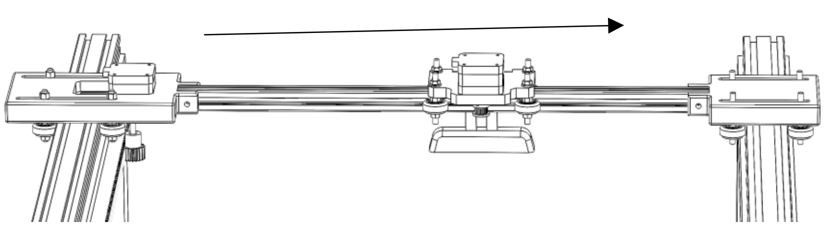

Fig 6. Y-axis movement with belt.

The motor control is done using A4988 stepper motor drivers, which are located on the CNC Shield V3 extension for ARDUINO UNO. The current for the motors is supplied by a 15V 2A power source.

**3. The operating mode of the software component.**

After the image acquisition process is completed, the resulting image needs to be processed to determine if the photographed object is the one being sought. The programming platform used for the program is LabVIEW, and the required library is Vision IMAQdx. The inventory program has two options: On-demand full inventory from a distance, where the camera will traverse and check each space on the shelf, or real-time dynamic inventory, which is performed every time a tool is added or removed from the shelf.

The shelf support where the tools are placed is similar to a matrix, with each cell assigned a unique tool. Above each cell, there is a QR code that provides the program with data about the corresponding tool (template). Additionally, the program utilizes the knowledge of the QR code's dimensions for camera calibration, enabling accurate measurements of the tool (Fig 7).

For additional verification, the program will compare the recorded mass with the known mass of the tool.

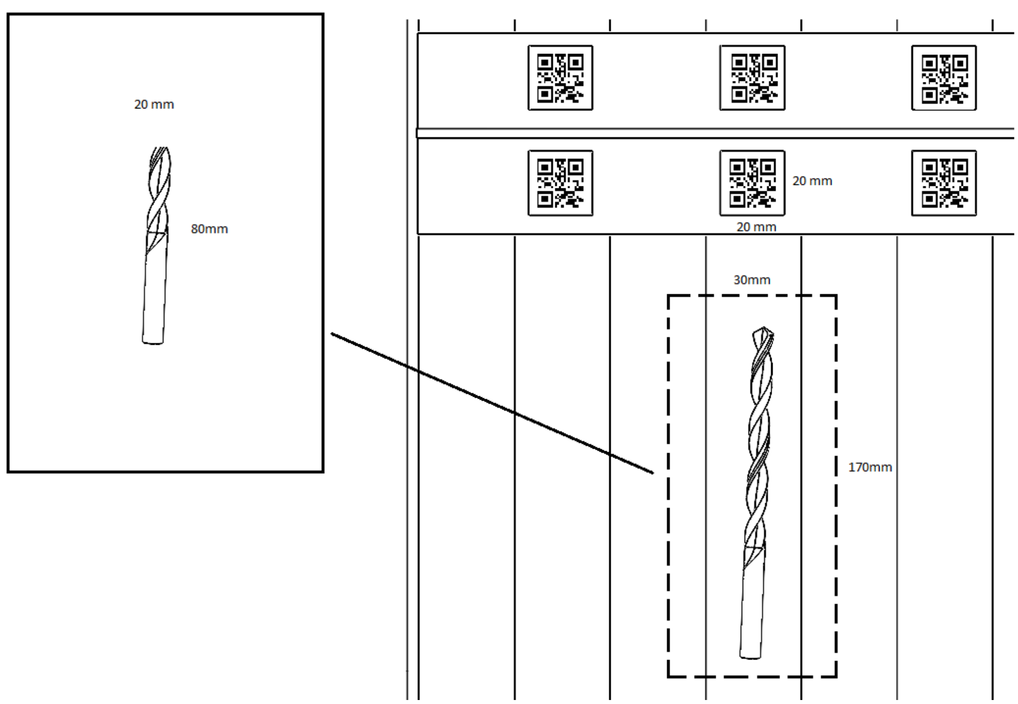


Fig 7. Software functionality demonstration

The inventory is in the form of a web page with authentication, where data from the database can be read or modified. Additionally, the latest image of the tool can be accessed.

## 4. Current status

As of 05/05/2023, the prototype of the system for inventorying cutting tools is still in progress, achieving the following objectives:

- Complete assembly of the shelf structure, installation of rails and rack (Fig 8)
- Assembly of the weight sensor system (Fig 8)
- Selection and gathering of all components, except for the mobile carriages which are to be 3D printed
- Familiarization with the image processing software and starting the programming (Fig 9)

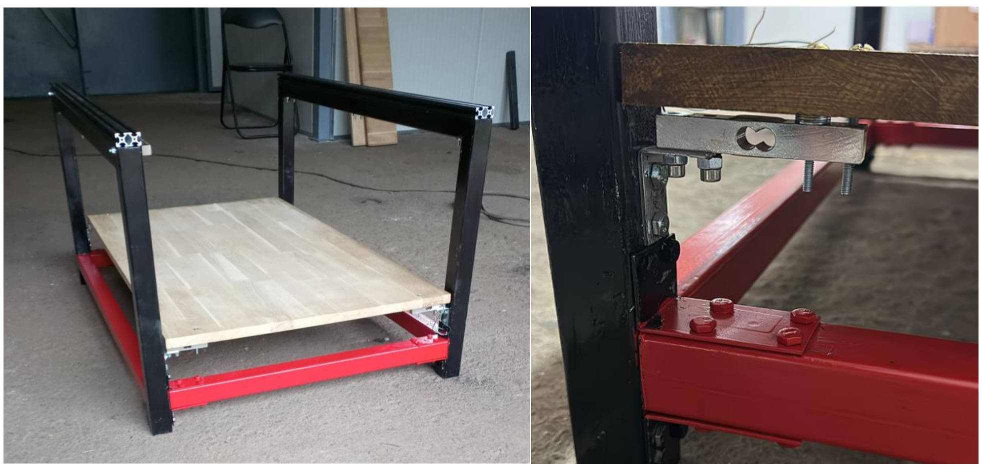

Fig 8. Experimental prototype

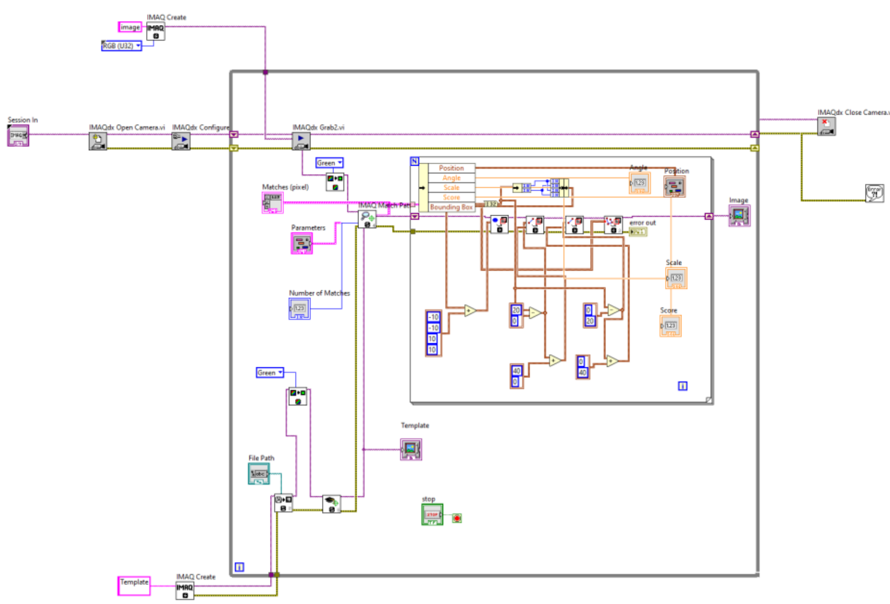


Fig 9. Labview-IMAQdx live image comparison with a template

## 5. Conclusion

The proposed system optimizes the inventorying process and has applicability beyond cutting tools. By integrating the automated inventorying system with other types of systems such as distribution or sorting, a storage system that does not require human intervention can be achieved.

Other suggestions for further improvement could include adding an automated sorting or ejection component for incorrectly placed items.

## 6. Bibliography

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