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An Embedded Vision–Based Autonomous System for Converting Hand-Drawn Glass Sketches into Engraved Objects

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INTRODUCTION & AIM

Conventional CNC and engraving systems require computers, complex software, and technical skills, which limit their accessibility for non-expert users. This work proposes a simple and intuitive human–machine interface that allows users to draw directly by hand on a glass surface.
The aim of this project is to develop an autonomous system capable of capturing hand-drawn sketches and automatically converting them into engraved or cut patterns on materials such as wood and plastic, without the need for a computer or display.

METHOD

The proposed system is composed of a glass drawing interface, an embedded vision module, and a mechatronic engraving platform. The workflow is as follows:

- The user draws a sketch manually on a transparent glass surface.
- A camera placed beneath the glass captures the drawing.
- The image is processed locally using a Raspberry Pi.
- Image processing algorithms extract contours and paths.
- The extracted paths are converted into G-code instructions.
- The G-code is sent to a Cartesian CNC system driven by stepper motors.
- A reference sensor ensures accurate positioning before execution.
- The machine reproduces the drawing as an engraved or cut pattern after pressing a start button.

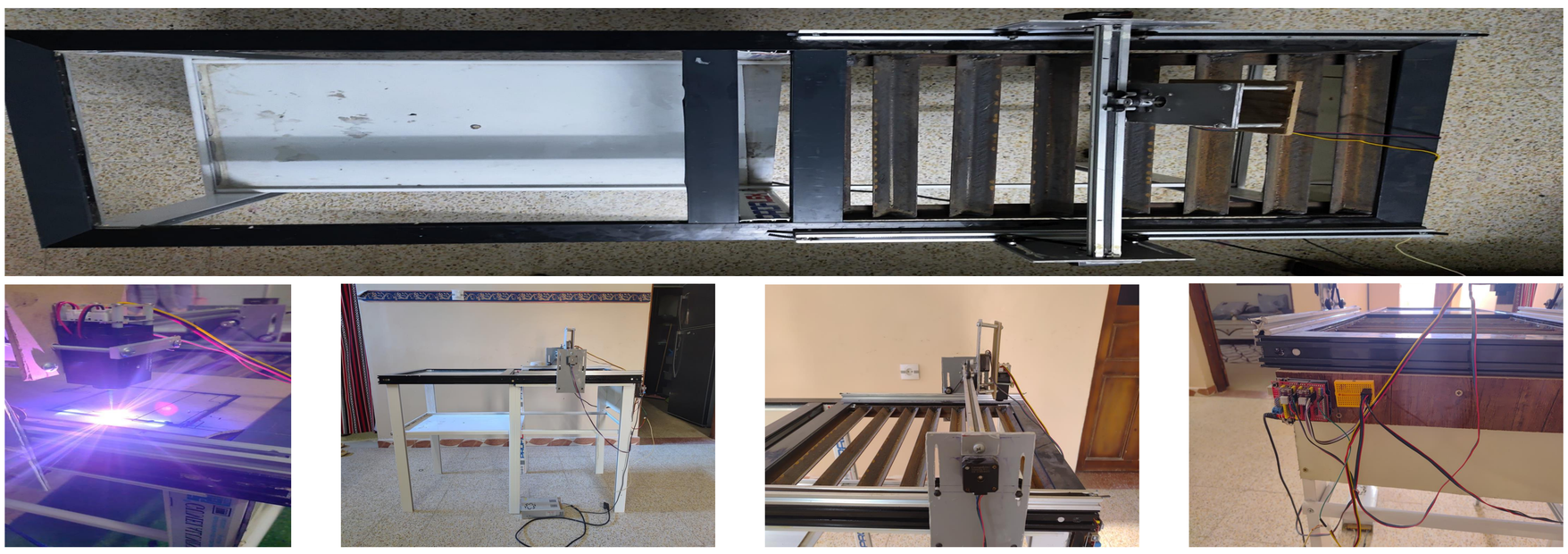

Figure 1. Experimental prototype of the proposed system showing the glass interface, motion mechanism, and control unit.

RESULTS & DISCUSSION

The developed prototype successfully demonstrates the feasibility of converting hand-drawn sketches into physical engravings.
Experimental tests show:

- Accurate contour extraction from hand-drawn inputs
- Stable and repeatable machine motion
- Successful engraving on wood and plastic materials
- Simple and intuitive user interaction without technical complexity
- The system reduces the need for external computers and simplifies digital fabrication workflows.
- Efficient image-to-G-code conversion using embedded processing
- Reliable positioning ensured by reference calibration
- Reduced system complexity compared to traditional CNC systems
- Potential for real-time operation and user interaction

In addition, the system demonstrates stable positioning accuracy due to the use of a reference sensor, which ensures consistent origin calibration before each operation. The conversion process from image to G-code is performed efficiently on the embedded platform, enabling real-time or near real-time execution. Furthermore, the integration of embedded vision eliminates the need for external computing systems, reducing system complexity and improving usability for non-expert users. The experimental prototype confirms the feasibility of low-cost digital fabrication using simple human interaction.

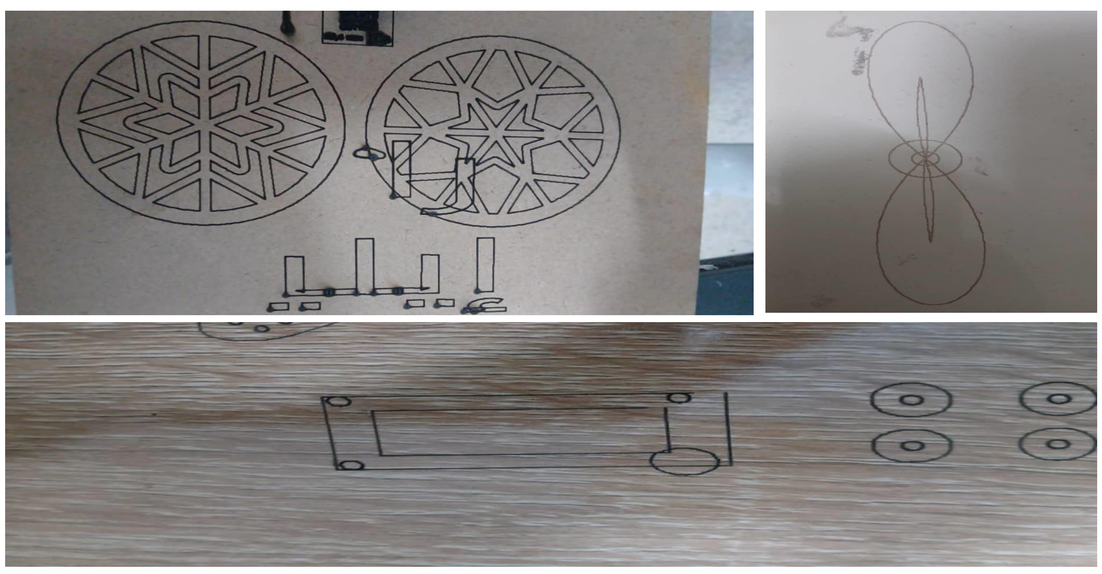

Figure 2. Examples of Hand-Drawn Sketches and Corresponding Engraved Results

Table 1. Performance Evaluation of the Proposed System

Metric	Result
Contour Detection	Accurate
Positioning Accuracy	±0.5 mm
Processing Time	2–5 s
Engraving Speed	500–1000 mm/min
Repeatability	Consistent results

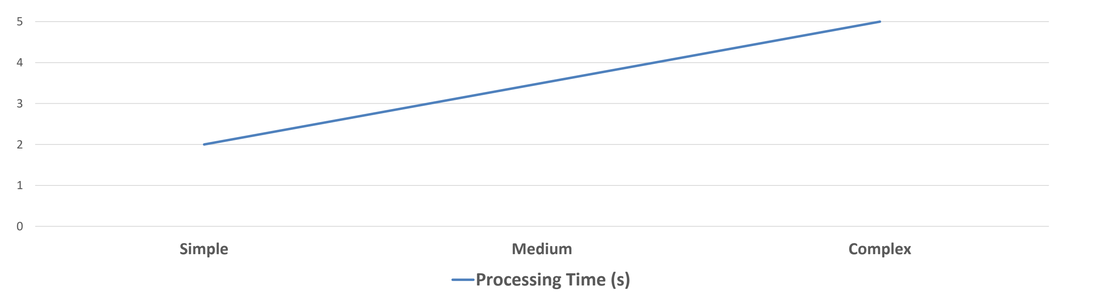

Figure 3. Processing Time vs Sketch Complexity

CONCLUSIONS

This work presents an autonomous embedded system for transforming hand-drawn sketches into engraved objects using embedded vision and CNC technology.
The proposed solution:

- Simplifies human–machine interaction
- Eliminates the need for computers and complex interfaces
- Provides a low-cost and accessible fabrication tool

FUTURE WORK/ REFERENCES/ACKNOWLEDGMENT

Future developments may include:

- Integration with smartphones for remote sketch transmission
- Improvement of image processing accuracy
- Addition of AI-based shape recognition
- Extension to additional materials and fabrication methods