



TÉCNICO
UNIVERSIDADE
DE LISBOA

AutoPrint

A Low-cost Automation Solution for 3D
Printing Services

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Team



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Advisor and Mentors

Coordinator

Luís Caldas de Oliveira

Professor at Instituto Superior Técnico, specializing in signal processing, innovation and entrepreneurship. With extensive experience in research and technology transfer projects funded by industry, FCT and the European Commission.

He is also co-creator of the first European Portuguese text-to-speech system, later commercialized by VoiceInteraction, a company he co-founded.

Former Vice-President of IST for Entrepreneurship (2009–2019), he currently leads the iStartLab and teaches courses in Innovation, Technology Transfer and Speech Processing.



Problem Definition



3D printing services face a critical productivity challenge: manual removal of printed parts and restarting new jobs consumes valuable time and limits continuous operation.



Operational Bottleneck

Constant production interruptions to manually remove parts



Resource Waste

Operators dedicated to repetitive, low value-added tasks



Limited Scalability

Impossible to operate 24/7 without constant human supervision



Risk of Damage

Improper handling can damage delicate or complex parts

Competitors and Previous Work



Prusa Pro AFS

Characteristics:

Complete automation system for print farms

Limitations:

High cost (€50k+), low flexibility, requires dedicated infrastructure.



Belt Systems

Characteristics:

Printers with automated moving bases (ex: Creality CR-30)

Limitations:

Requires modification, not suitable for delicate parts or high precision.



Handcrafted Solutions

Characteristics:

Adapted industrial robotic arms

Limitations:

Complex, slow, higher cost, and lacks error detection.

Our Differentiated Advantage

A lower cost, modular and adaptable solution for automating procedures across diverse print farm configurations, integrated with computer vision for part quality control.

Target Audience



Additive Manufacturing

Small and medium companies operating print farms with 10–50 printers, looking to increase efficiency without large infrastructure investments.



Rapid Prototyping Centers

Development labs that need agile and continuous production to quickly respond to client requests.



Educational Institutions

Universities and technical training centers that manage multiple printers for research projects and hands-on teaching.

Technological Solution

System Overview

We aim to develop an automated part-removal system that employs a linear motor to flex the print bed, detaching the part, and then the printer's structural arm subsequently removes it. Utilizing computer-vision, the system autonomously inspects the components, ensuring continuous human-free operation.

Integrated Technologies



Computer Vision System

Cameras for error detection and quality control with dedicated lighting for dark environments.



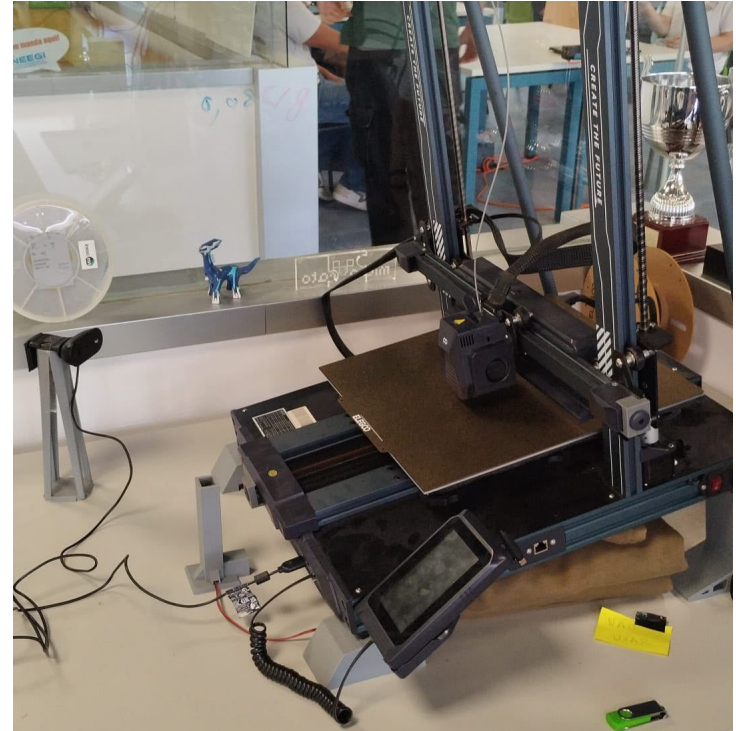
Total Part Removal

Specialized mechanism allowing for continuous 24/7 autonomous production cycles.



Coordination App

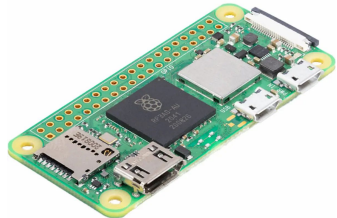
Advanced software interface for real-time management and fleet coordination.



System Architecture

Automation Hardware

- Raspberry Pi 5 (Server)
- Raspberry Pi Zero W
- Logitech C505 Camera
- Linear Actuator
- LED Lighting System



Software Platform

- Web/App Interface
- Monitoring Dashboard
- Logging System
- Multi-Printer Coordination

System Flow



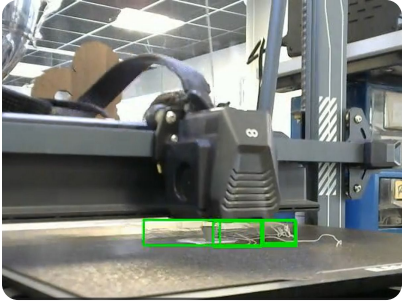
Centralized Hardware

Native integration between processing via **Raspberry Pi 5** and physical actuation modules

SYSTEM OVERVIEW

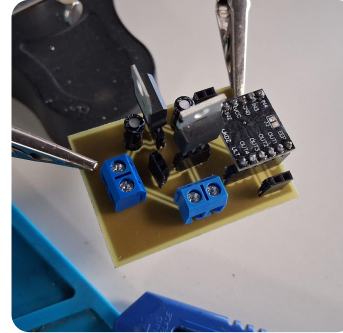
Camera Monitoring → Raspberry Pi 5 → Computer Vision & Machine Learning → Decision Engine → Linear Actuator + Printer Motion System → Part Removal → Next Print Job Starts Automatically

Achieved Results



Error Detection (CV)

Computer vision to identify failures in real time.



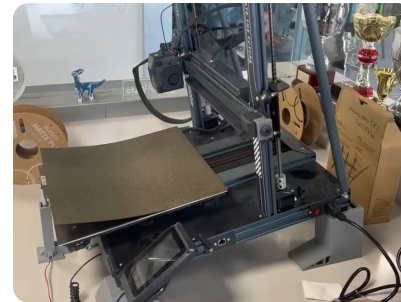
Printed Circuit Board

Designed with low-cost in mind



Flexible Bed

Linear actuator for automatic piece detachment.



Base Supports

Reinforced structure for stable 10° inclination.

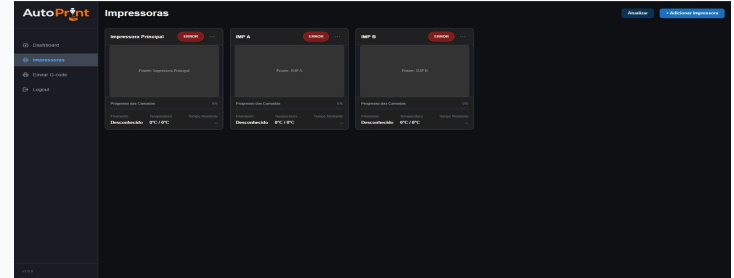
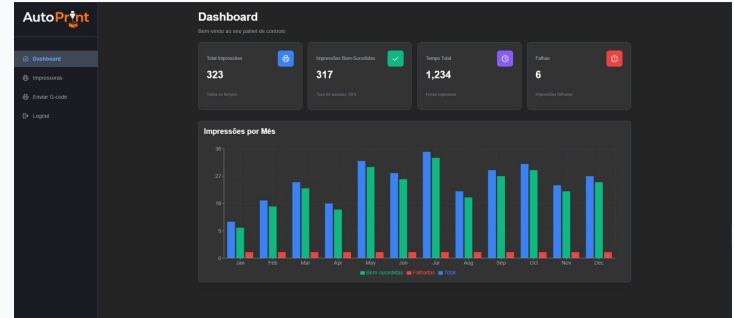
Achieved results - WebApp

Centralized Print Farm Management

- Development of a dedicated web platform for monitoring and managing multiple 3D printers from a single interface.
- Designed with scalability in mind to support industrial and print farm environments.

Integrated Error Detection System

- Integration with an AI-based print monitoring system, enabling automatic detection of printing failures and anomalies.



Key Differentiator

The direct integration of an error detection system with the platform allows operators to monitor the entire print farm and receive real-time failure alerts through a single interface. Developed with Invicta3D necessities in mind, focusing on efficient multi-printer management, waste reduction, and increased productivity.

Achieved results - WebApp



Real-time Alert

User gets notification with live image of Print State



Successful Print

Remove and auto queue next print



Error While Printing

User receives photographic evidence and decides if:

- System tries to remove and auto queue next print
- It needs Manual Removal

Achieved Results - Our Computer Vision Model

PERFORMANCE METRICS FOR FIRST ITERATION

Samples

232

Photos Processed

Precision

63%

Accurate Detections

Detection Rate

51%

Targets Identified

Status & Outlook

- **Current Status:** Functional, undergoing continuous optimization.
- **Next Goal:** Expand dataset to improve detection in complex cases.

The model is Self-Taught

We anticipate exponential performance improvements as the dataset grows.

Achieved Results - Obico Computer Vision Model

PERFORMANCE METRICS FOR FIRST ITERATION

Samples

50

Videos Processed

Precision

98%

Accurate Detections

Detection Rate

100%

Targets Identified

Status & Outlook

- **Current Status:** OBICO successfully detects possible print failures and sends webhook notifications to the backend.
- **Integration Result:** The backend can receive real-time failure events such as PrintFailure and PrintPaused.

The Obico model can be Self Hosted or Cloud hosted

Which makes obico more adaptable to the needs of the user. It provides reliable operational failure detection while supporting future YOLO improvement through collected error data.

Feedback

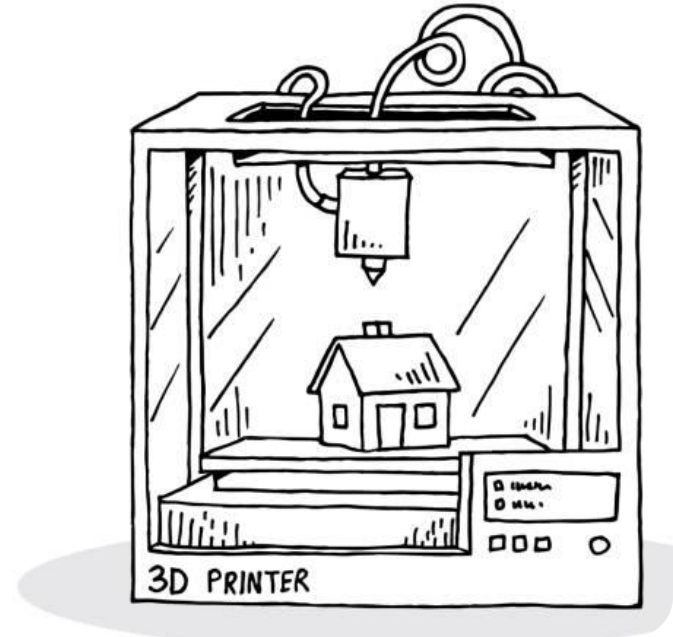
We had the pleasure of getting feedback from **Invicta 3D** and **Imprima3D** :

” Unanimous Feedback:

"Companies confirm that the solution has significant potential to enhance their operations and workflows. Notably, one partner is especially enthusiastic about testing our control software (app)."

- Technical simplicity and effectiveness of the flexure-based removal
- Adoption of standard, user-friendly hardware components, simplifying assembly, maintenance, and long-term support.
- Strong value proposition of the mobile application for remote monitoring and centralized production management.
- Compact system layout, offering advantages over solutions that require the storage and handling of multiple build plates.

The feedback received indicates that our solution has the potential to meaningfully improve their business operations and workflow.



Costs and Benefits



Costs

First investment:

- Raspberry Pi 5 (Server) \approx 80 €

Hardware (per printer):

- Linear Motor \approx 30€
- Electronic Circuit \approx 5€
- Printer Supports \approx 5€
- Raspberry Pico W \approx 20€*

* *Not needed for printers with native API access*



Benefits

- User-friendly and easy to set up
- Minimal space, high efficiency
- Live feed of printers
- Print error detection
- **Enables human-free operation**

Contribution of each team member (1)

Manuel Vaz	Bruno Lobito	João Nunes
Computer Vision Algorithms and Integration	Computer Vision Algorithms and Integration	Raspberry PI communication with sub-systems
Prototype Requirements and Architecture	Website Development/Updates	Poster
Bill of Materials	Prototype Requirements and Architecture	Interviews
PCB design	Bill of Materials	Printed Part Removal System
Outreaching to Partners	Web App (Backend) Development and API Integration	Website Updates
Video	Pitch Deck	

Contribution of each team member (2)

João Pires	David Soares	Gonçalo Martins
Interviews and Outreaching	Printed Part Removal System	Full-stack development and API Integration
CAD - 3D Modelling	Processing Algorithms	Website Development/Updates
Printed Part Removal System	Computer Vision Algorithms	Computer Vision Algorithms
Pitch deck	Light systems	Prototype Requirements and Architecture
Website Updates	Website Updates	Bill of Materials
		Poster

Important Links and Video

- **Website:** <https://web.tecnico.ulisboa.pt/ist1110017/>
- **Blog:** <https://web.tecnico.ulisboa.pt/~ist1110017/blog/>
- **Video:** https://docs.google.com/file/d/16JcbZGSNYgYmrEdEwVT_bVuEYVQjthSR/preview