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GUI FOR REAL-TIME MONITORING OF FDM 3D PRINTING USING SERIAL DATA

BY

**FLORIN-DANIEL EDUȚANU^{1,*}, DRAGOȘ-FLORIN CHITARIU^{1,2},
FLORIN CHIFAN¹, EMILIAN PADURARU¹ and GABRIEL SIGNEANU¹**

¹“Gheorghe Asachi” Technical University of Iași, Faculty of of Machine Manufacturing and
Industrial Management, 59A, Prof. D. Mangeron Blvd., 700050, Iași, Romania

²Academy of Romanian Scientists, Ilfov 3, 050044 Bucharest, Romania

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Abstract. Additive manufacturing based on Fused Deposition Modelling (FDM) technology is increasingly being integrated into the Industry 4.0 context, where real-time monitoring and process transparency are essential for improving the reliability of the manufacturing process. This paper presents the development of a graphical user interface (GUI) for real-time monitoring of FDM 3D printing using serial data acquisition. The experiments were carried out on a Creality Ender 3 S1 Pro printer, from which parameters such as nozzle temperature, build plate temperature, feed rate and the position of the current layer were collected and displayed in real time. Real-time monitoring of FDM 3d printing using serial data proposed is feasible for Taguchi based experimental setups offering great traceability, process monitoring and report generation. Visual monitoring of the process was carried out using a GoPro camera. The developed system contributes to increasing process transparency and improving the traceability of parameters and defects that occur during printing.

Keywords: cyber-physical systems, process traceability, defect detection, additive manufacturing, Industry 4.0.

*Corresponding author; *e-mail*: florin-daniel.edutanu@staff.tuiasi.ro

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1. Introduction

Industry 4.0 represents the digital transformation of industrial processes through the integration of smart technologies, cyber-physical systems and real-time data exchange. The concept is associated with the smart factory, where industrial equipment, software systems and monitoring technologies are interconnected to increase the productivity, flexibility and transparency of manufacturing processes. Within Industry 4.0, production processes are becoming increasingly digitized, enabling continuous monitoring, real-time decision-making and the optimization of industrial processes.

The development of the Industry 4.0 concept is based on several technological pillars, such as Big Data, the Internet of Things (IoT), Cyber-Physical Systems (CPS), Cloud Computing, Simulation/Digital Twin, Robotics and Additive Manufacturing. Of these pillars, this paper focuses in particular on Additive Manufacturing, Cyber-Physical Systems, Simulation/Digital Twin and , as these contribute directly to the development of a real-time monitoring system for FDM 3D printing. At the same time, Industry 4.0 principles such as interoperability, information transparency, real-time capability and modularity are integrated into the architecture of the graphical interface developed.

Additive manufacturing based on Fused Deposition Modelling (FDM) technology is increasingly used in industrial and research applications due to the flexibility of the process and low manufacturing costs. However, the FDM process is heavily influenced by parameters such as nozzle temperature, build plate temperature, layer height, feed rate and infill configuration. Inappropriate settings can lead to defects such as warping, layer detachment, material accumulation or extrusion instabilities, affecting the quality of the manufactured parts. For this reason, real-time monitoring and process transparency are becoming key elements in experimental studies on FDM 3D printing.

Earlier studies have shown that combining different types of monitoring in cyber-physical systems can help identify defects and improve process transparency in FDM additive manufacturing (Kravets *et al.*, 2025).

Therefore, the interest has increasingly focused on serial monitoring, defect detection, video monitoring and the development of digital representations of the manufacturing process. These systems aim to correlate process parameters with the physical condition of the printed part in order to improve process monitoring and traceability.

The aim of this paper is to develop a graphical user interface (GUI) for real-time monitoring of FDM 3D printing using serial data acquisition and video monitoring. The developed system enables real-time visualization of process parameters, monitoring of the current layer, and process traceability through the recording of parameters and documentation of defects occurring during printing.

2. Materials and Method

2.1. Experimental configuration

The experimental system used in the research was developed to monitor the FDM 3D printing process in real time using serial data acquisition and video monitoring (see Fig. 1). The experimental setup consists of a Creality Ender 3 S1 Pro 3D printer, a GoPro camera used for visual monitoring of the process, and a computer running Windows used for data processing and display.

To improve visual monitoring of the experimental process, a PATONA Premium SLPB40R 40W RGB LED lamp was also used to provide uniform illumination of the printing area and to enhance the clarity of the images captured during video monitoring. The lighting system contributed to a more accurate observation of defects occurring during printing and to an improvement in the quality of the snapshot images used in the experimental documentation.

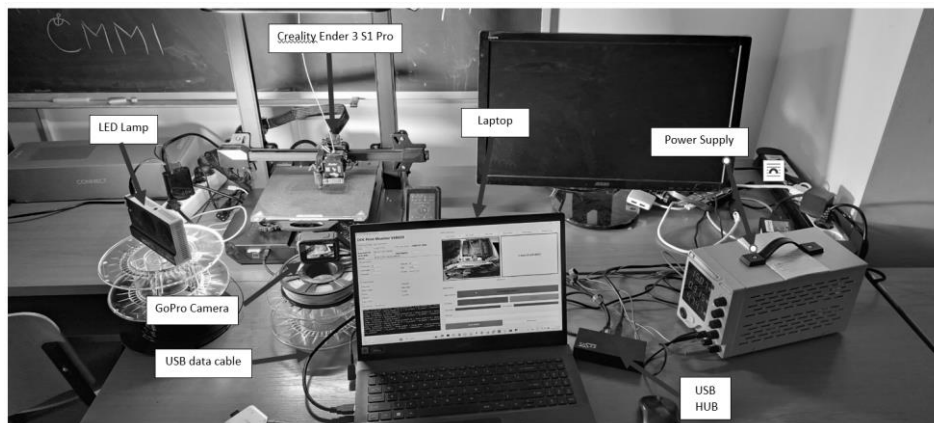


Fig. 1 – Experimental configuration of the real-time FDM monitoring system.

The equipment was connected via a 4-port Exsys USB hub, used to stabilise the serial connections and connect both the 3D printer and the video camera to the monitoring system simultaneously. Data transfer was carried out using USB 3.2 Gen 2 USB-A to USB-C cables, with a transfer rate of up to 10 Gbps. The Exsys USB hub was powered using a Rosfix 32V 5A adjustable laboratory power supply, used to ensure a stable power supply to the equipment connected within the experimental setup.

The Python programming language was used to develop and implement the monitoring system, together with the Tkinter, PySerial, OpenCV and FFmpeg libraries. The Tkinter library was used to develop the graphical user interface, PySerial for serial communication with the 3D printer, OpenCV for

image processing, and FFmpeg for displaying and processing the video stream from the GoPro camera.

Communication between the 3D printer and the computer is achieved via a serial connection, enabling the real-time collection of process parameters and the continuous updating of the information displayed in the graphical interface.

2.2. Architecture of the graphical user interface

A graphical user interface provides a visual environment that allows users to interact with a system through buttons, menus, graphical elements and real time data visualization.

In monitoring and industrial applications, graphical user interfaces are commonly used to improve process control, facilitate data interpretation and simplify user interaction with hardware and software components.

The graphical interface developed has a modular structure and includes several areas dedicated to monitoring and documenting the FDM 3D printing process (see Fig. 2). The system allows both the input of experimental parameters and the real-time display of data from the printer.

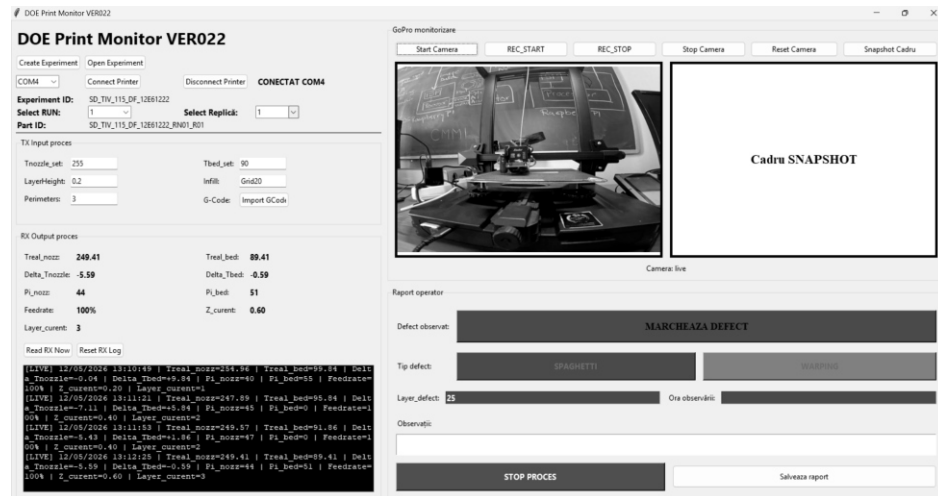


Fig. 2 – Architecture of the DOE Print Monitor graphical user interface.

The ‘TX Input process’ module is used to automatically import and display the main printing parameters extracted from the G-code file associated with the active experimental run. The imported parameters include the nozzle set temperature, the print bed temperature, the layer height and the infill configuration. In version VER022, the software automatically identifies the corresponding G-code file from the active RUN directory and updates the

interface fields after pressing the “Import GCode” button. This mechanism reduces manual data entry errors and ensures direct synchronization between the experimental configuration and the graphical monitoring interface.

The “RX Output process” module is used for real-time monitoring of processed parameters from serial data. The interface displays the actual nozzle temperature (Treal_nozz), the actual print bed temperature (Treal_bed), the temperature deviations for the nozzle and print bed (Delta_Tnozzle and Delta_Tbed), the instantaneous heating power for the nozzle and bed (Pi_nozz and Pi_bed), the process feedrate, the current position on the Z-axis, and the current print layer. The parameters are continuously updated throughout the printing process.

Video monitoring of the process is carried out using the ‘GoPro monitoring’ module, which allows the video feed to be displayed in real time, enables recording to be started and stopped, and allows snapshot images to be captured during printing. Video monitoring makes it easier to identify defects and correlate them with the process parameters that are continuously monitored.

The interface also includes a module dedicated to process reporting and traceability, called ‘Operator Report’. This module allows users to record defects observed during printing, save snapshot images and automatically generate test reports in JSON and TXT formats. In addition, information regarding the time the defect occurred and the current print layer is saved, contributing to the traceability of the manufacturing process.

2.3 Serial data acquisition

Various authors consider high sampling rate data acquisition to be very important in real-time monitoring applications for manufacturing processes and defect detection. In their opinion, this aspect can improve process analysis, facilitate anomaly identification and support the evaluation of system behavior during operation (Chitariu *et al.*, 2024).

Serial data acquisition is widely used in industrial and monitoring applications for the real time collection, transmission and analysis of process parameters exchanged between electronic devices and control systems.

Serial data acquisition was performed via serial communication using the COM4 port and a baud rate of 115200. Serial communication enables the real-time collection of process parameters from the 3D printer and the continuous updating of the information displayed in the graphical user interface.

To monitor process parameters, the M105, M114, and M220 commands were used, transmitted and interpreted in real time by the developed system.

The M105 command is used to retrieve the actual nozzle temperature, the actual print bed temperature, the set temperatures, and the instantaneous heating power for the nozzle and bed. The values are extracted from the serial response returned by the printer, in the form “T: / B: / @: / B@:”.

For example, the M105 command returns data in the form: ok T:210.0 /210.0 B:60.0 /60.0 @:127 B@:80 where:

- T: represents the actual nozzle temperature,
- B: represents the actual print bed temperature,
- @: represents the instantaneous power applied to the nozzle,
- B@: represents the instantaneous power applied to the print bed.

Some authors also consider that displacement monitoring can contribute to improving the accuracy of 3D printing by identifying and compensating for positioning errors (Munteanu *et al.*, 2021). The M114 command is used to determine the current position on the X, Y, and Z axes; this information is used to calculate the current print position and to determine the current layer of the manufactured part.

Another example is represented by the M114 command, which returns data in the following format: X:120.000 Y:85.000 Z:4.200 E:356.421 where:

- X represents the current position on the X-axis,
- Y represents the current position on the Y-axis,
- Z represents the current position on the Z-axis,
- E represents the amount of extruded material.

Within the developed system, the Z-axis position value is used to determine the current print layer. For example, for a layer height of 0.2 mm and a Z-position of 4.2 mm, the system determines that the print is approximately at layer 21.

The M220 command is used to monitor the feedrate of the printing process, expressed as a percentage of the nominal process speed. The M220 command returns data in the form FR:100% where FR represents the current feedrate of the printing process as a percentage of the nominal speed set in the G-code file.

2.4. Experimental methodology

The experimental methodology defines the sequence of procedures, equipment and parameters used to ensure the repeatability and accuracy of the research process. It provides a structured framework for data acquisition, monitoring and analysis under controlled experimental conditions.

In engineering research, the experimental methodology is commonly used to validate system performance, evaluate process behaviour and compare the influence of different operating parameters on the obtained results.

In our case the experimental methodology was predicated on real-time monitoring of the FDM 3D printing process and the identification of defects that occurred during printing. The experiments were conducted using a Taguchi design of experiments (DOE), in which parameters such as nozzle temperature,

print bed temperature, layer height, infill configuration, and the number of perimeters were varied.

The primary objective of the developed system was to monitor the process and identify, in real time, defects specific to FDM printing, particularly spaghetti and warping defects, that occurred during the Taguchi experiments. The experimental design was utilized to generate a range of printing conditions, while the graphical interface was employed to monitor parameters and observe the behavior of the manufacturing process.

During each experiment, parameters from the serial communication and images from the GoPro video system were monitored in real time. The developed system facilitates the correlation of defects observed during printing with the monitored process parameters and the current print layer. Consequently, defects that have been identified can be directly associated with the process parameter values that were recorded at the time of their occurrence.

The system's ability to continuously monitor the position on the Z-axis and determine the current layer facilitates the localization of defects within the printing process, thereby enhancing the experimental traceability of the FDM process. Furthermore, the implementation of video monitoring and the utilization of the snapshot function facilitate the creation of a visual record of defects identified during experimental procedures.

3. Results and Discussion

3.1. Real-time monitoring of the FDM process

Real time monitoring enables the continuous observation and analysis of process parameters during system operation.

It is widely used in industrial environments to improve process control, detect anomalies and support rapid decision making based on live data acquisition.

The developed system enables real-time monitoring of the main parameters of the FDM 3D printing process via serial communication and the developed graphical interface.

Real-time data acquisition supports process evaluation and provides operators with immediate feedback on potential non-conformities (Kondrat *et al.*, 2025).

During printing, the interface continuously displays the actual temperature of the nozzle and the print bed, the process feed rate and the current position on the Z-axis, which is used to determine the current layer of the print.

Real-time temperature monitoring allows for the observation of temperature fluctuations that occur during printing and the identification of any deviations from the set values. At the same time, feed rate monitoring provides

information on the dynamics of the manufacturing process and the stability of the extrusion process.

Real-time monitoring plays an important role in maintaining process stability and improving the consistency and reliability of additive manufacturing processes (Li *et al.*, 2026).

A key feature of the developed system is the determination of the current layer based on the position along the Z-axis. This function enables the precise localization of defects that occur during printing and their correlation with the process parameters monitored at the time the defect occurred.

The RX Output interface (see Fig. 3) thus allows for the simultaneous visualization of process parameters and the progress of the print in real time.

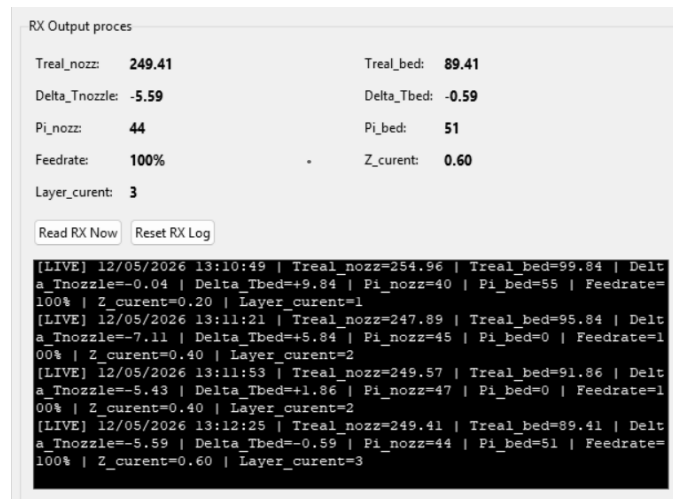


Fig. 3 – Real-time monitoring of FDM process parameters through the developed RX Output interface.

The obtained results demonstrate that the developed interface enables continuous monitoring of the FDM process by simultaneously displaying the thermal parameters, feedrate and current printing layer, allowing rapid identification of process variations during printing.

The integration of real time serial data acquisition and graphical visualization contributes to improved process traceability and facilitates the analysis of printing conditions throughout the manufacturing operation.

3.2. Video monitoring and defect detection

Video monitoring is commonly used in industrial and research applications to provide continuous visual observation of processes, equipment behaviour and potential defects during system operation. Monitoring of the

process was carried out using a GoPro camera integrated into the experimental setup. The video feed is displayed in real time within the graphical interface and allows for continuous monitoring of the physical condition of the printed part.

During the experiments, several types of defects specific to the FDM process were observed, such as warping, layer detachment, material accumulation and spaghetti-type defects. Video monitoring allows for the rapid identification of defects and their correlation with the parameters monitored in real time at the moment the defect occurs.

Spaghetti defects were observed when the extruded material was deposited uncontrollably outside the intended printing area, generating irregular filament accumulation around the printed component. These defects were generally associated with layer detachment, loss of adhesion or interruptions in the normal deposition process. Spaghetti is a more severe defect, where the filament is extruded uncontrollably, often due to a misalignment or failure in the print setup, resulting in a tangled mess of filament rather than a coherent structure (Sani *et al.*, 2026).

Through real-time monitoring and video visualization, the developed system allowed rapid identification of the defect occurrence and correlation with the current process parameters and printing layer.

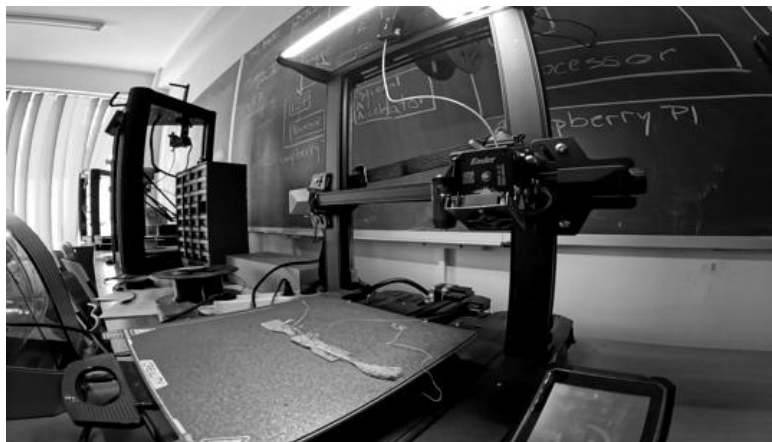


Fig. 4 – Real-time monitoring of FDM process parameters through the developed RX Output interface Spaghetti defect identified.

Fused Deposition Modeling (FDM) often faces problems in the quality of the parts due to formation of defects such as stringing, dimensional inaccuracy and warping (Rajamani *et al.*, 2025).

Warping defects were observed in particular when there were inappropriate combinations of nozzle temperature and print bed temperature, leading to the partial detachment of the part from the print surface.

Furthermore, spaghetti and material accumulation defects were associated with instabilities in the extrusion process or with a loss of adhesion of the printed layer.

By using the snapshot function, the system allows images corresponding to the moment the defect occurred to be saved, contributing to the subsequent analysis of the manufacturing process behavior.



Fig. 5 – Real-time monitoring of FDM process parameters through the developed RX Output interface Warping defect identified.

3.3. Process traceability

Traceability represents the ability to monitor, record and identify the evolution of a product, process or system throughout all stages of operation and data acquisition. In industrial applications, traceability is essential for process control, quality assurance and the analysis of manufacturing parameters associated with a specific experimental or production activity.

Before the experimental process begins, each printed sample is assigned a unique identification code automatically generated by the developed application, for example SD_TIV_115_DT_12E61222_RN01_R01. The prefix SD_TIV_115 is generated based on the specimen geometry defined according to the ASTM D638 Standard Test Method for Tensile Properties of Plastics, where SD represents the specimen category, TIV indicates the ASTM Type IV specimen geometry and 115 represents the characteristic specimen dimension extracted from the selected model. The sequence DT corresponds to the experimental method configuration, indicating a DOE Taguchi experiment, while 12E61222 represents the automatically generated experimental timestamp. The suffixes RN01 and R01 indicate the experimental run number and the replica number associated with the monitored sample.

A key advantage of the developed system is that it enables traceability of the FDM 3D printing process. The graphical interface allows for the recording of monitored parameters, the saving of snapshot images, and the automatic generation of experimental reports in JSON and TXT formats.

For each event observed during printing, information such as the timestamp, the current print layer, the position on the Z-axis and the type of defect identified is saved. This information allows the experimental conditions associated with the occurrence of defects to be reconstructed and a detailed analysis of the influence of process parameters to be carried out.

The identification of defects in the current layer is a key element in the analysis of the FDM process, as it enables a direct correlation between process parameters and the physical behaviour of the printed part. Furthermore, the automatically generated reports help to organise and document the experiments carried out.

By integrating serial monitoring, video monitoring and the reporting system, the developed solution helps to increase the transparency and traceability of the additive manufacturing process.

3.4. Integration of Industry 4.0 principles

The design principles of Industry 4.0 facilitate the integration of various Industry 4.0 technologies by system and application designers for the successful development and implementation of sustainable Industry 4.0 systems (Edutanu *et al.*, 2025).

Industry 4.0 principles are based on the integration of digital technologies, intelligent systems and automated data exchange within industrial processes. The basic design principles of I4.0 are real-time evaluation, virtualization interoperability, decentralization, and horizontal, vertical, and end-to-end integration (Varriale *et al.*, 2025; Edutanu *et al.*, 2025). These principles support real time monitoring, connectivity, interoperability and data driven decision making to improve manufacturing efficiency, flexibility and process control.

The system developed incorporates principles specific to Industry 4.0 through the use of serial communication, real-time monitoring and digital representation of the FDM process.

The graphical interface enables continuous data exchange between the 3D printer and the software system, helping to increase process transparency and enable continuous monitoring of manufacturing parameters.

The developed GUI allows real-time acquisition and visualization of process parameters, including nozzle temperature, bed temperature, feedrate and current printing layer, while simultaneously integrating video monitoring and experimental reporting functions. In addition, the developed system supports process traceability through automatic data archiving, snapshot saving and report generation associated with each monitored experiment.

Table 1
Integration of Industry 4.0 principles within the developed GUI system

Industry 4.0 Principle	GUI Implementation
Interoperability	Serial communication
Virtualization	Digital process visualization
Real-time capability	Live monitoring
Technical assistance	GUI infrastructure support
Modularity	Modular GUI architecture
Decentralization	Automatic data archiving

Table 1 presents the correlation between the main Industry 4.0 principles and their implementation within the developed monitoring system. The proposed solution integrates interoperability through serial communication, virtualization through digital process visualization and real-time capability through continuous live monitoring of the FDM process. Furthermore, the modular architecture of the GUI and the automatic management of experimental data contribute to the implementation of modularity, technical assistance and decentralized data management principles within the developed system.

4. Conclusions

This paper presented the development of a graphical interface for real-time monitoring of the FDM 3D printing process using serial data acquisition and video monitoring. The developed system was implemented and experimentally tested on a Creality Ender 3 S1 Pro printer, using serial communication to collect process parameters and a GoPro camera for visual monitoring of the manufacturing process.

The graphical interface developed enables continuous monitoring of the main parameters of the FDM process, such as nozzle temperature, build plate temperature, feed rate and current position on the Z-axis. The current print layer is determined based on the current position on the Z-axis; this function enables the localisation of defects and their correlation with the process parameters monitored at the time the defect occurred. The system thus allows the monitoring of the printing process in real time and the identification of deviations occurring during manufacture.

A key aspect of the research is the integration of serial monitoring and video monitoring into a single graphical interface. Video monitoring using a GoPro camera enables the physical condition of the printed part to be observed and defects such as warping, layer detachment, material accumulation or spaghetti-like defects to be identified. Through the snapshot capture function and the reporting of observed events via, the system enables experimental

documentation of the process and subsequent analysis of defects that occur during printing.

A key feature of the developed system is the ability to ensure traceability of the FDM 3D printing process. The interface allows for the saving of monitored parameters, the automatic generation of experimental reports in JSON and TXT formats, and the recording of information relating to the occurrence of defects. In addition, information regarding the timestamp, current layer and position on the Z-axis is saved, contributing to the reconstruction of the experimental conditions associated with the manufacturing process. Through these functions, the system facilitates experimental analysis and the correlation of process parameters with defects observed during printing.

The experimental results obtained demonstrate that the graphical interface developed helps to increase the transparency of the manufacturing process and improve real-time monitoring of FDM 3D printing. The integration of serial communication, video monitoring and the reporting system enables the development of an experimental system specific to the Industry 4.0 concept, based on continuous monitoring and the digitisation of the additive manufacturing process.

Through the functions it incorporates, the system developed can serve as a foundation for future developments aimed at automating the monitoring process and integrating artificial intelligence algorithms for the automatic detection of defects.

In this regard, future research directions aim to integrate YOLO models for real-time defect identification and to develop advanced Digital Twin representations for monitoring and analysing the FDM 3D printing process.

REFERENCES

- Chitariu D.-F., Horodincu M., Mihai C.-Gh., Bumbu N.-E., Dumitras C.G., Seghedini N.-E., Edutanu F.-D., *Condition Monitoring of a Three-Phase AC Asynchronous Motor Based on the Analysis of the Instantaneous Active Electrical Power in No-Load Tests*, Applied Sciences, 14(14), (2024), doi:10.3390/app14146124.
- Edutanu F.-D., Ciorap M., Grigoruță L.-C., Chitariu D.-F., Bejenaru I.A., Signeanu G., *A Systematic Review of the Principles of Industry 4.0*, Bulletin of the Polytechnic Institute of Iași, Machine constructions Section, 71(2), (2025), doi:10.2478/bipcm-2025-0017.
- Kondrat M., Anastasiia Nazim, Kamil Zidek, Jan Pitel, Peter Lazorík, Michal Duhancik, *Real-Time Monitoring of 3D Printing Process by Endoscopic Vision System Integrated in Printer Head*, Applied Sciences, 15 (2025), doi:10.3390/app15179286.
- Kravets A., Salnikova Natalia A., Strukova Inna, *A Cyber-Physical Approach to 3D Printing Monitoring*, Bulletin of the Saint Petersburg State Institute of

- Technology (Technical University) (2025), doi:10.36807/1998-9849-2025-75-101-70-77.
- Li Y., Ke Wang, Guangming Zhang, Daosen Song, Peikai Duan, Yice Wang, Wei Ge, Hongbo Lan, *Real-time Monitoring and Feedback Control of Electric-Field-Driven Microscale 3D Printing Based on Machine Vision and Deep Learning*, Journal of Manufacturing Processes, 157 (2026), doi:https://doi.org/10.1016/j.jmapro.2025.12.007.
- Munteanu A., Chitariu D.-F., Horodincă M., Dumitras C.G., Negoescu F., Savin A., Chifan F., *A Study on the Errors of 2D Circular Trajectories Generated on a 3D Printer*, Applied Sciences, 11(24), (2021), doi:10.3390/app112411695.
- Rajamani R., Aswin T.M., Dhinnesh S., Guru Prasath K.S., Hasina M., *Vision-guided Process Optimization for Stringing Reduction in FDM 3D Printing Using RSM*, IOP Publishing Ltd. (2025), doi:10.1088/2631-8695/ae0d44.
- Sani A.R., Zolfagharian Ali, Kouzani Abbas Z., *Automated Defects Detection in Extrusion 3D Printing Using YOLO Models*, Journal of Intelligent Manufacturing, 351-371 (2026), Retrieved from 10.1007/s10845-024-02543-8.
- Varriale V., Antonello Cammarano, Francesca Michelino, Mauro Caputo, *Interconnected Industry 4.0 Technologies: Identifying Current Network Value and Integration Opportunities*, Journal of Industrial Information Integration, 45 (2025), doi:https://doi.org/10.1016/j.jii.2025.100838.

INTERFAȚĂ GRAFICĂ PENTRU MONITORIZAREA ÎN TIMP REAL A IMPRIMĂRII 3D FDM PRIN INTERMEDIUL DATELOR SERIALE

(Rezumat)

Fabricarea aditivă bazată pe tehnologia Fused Deposition Modeling (FDM) este tot mai integrată în contextul Industry 4.0, unde monitorizarea în timp real și transparența procesului reprezintă elemente importante pentru creșterea fiabilității procesului de fabricație. Lucrarea prezintă dezvoltarea unei interfețe grafice (GUI) pentru monitorizarea în timp real a imprimării 3D FDM utilizând achiziția datelor seriale și monitorizarea video.

Sistemul experimental a fost implementat utilizând o imprimantă Creality Ender 3 S1 Pro, o cameră GoPro și un calculator cu sistem de operare Windows. Parametrii monitorizați includ temperatura nozzle-ului, temperatura patului de imprimare, feedrate-ul, poziția pe axa Z și stratul curent al imprimării.

Monitorizarea video permite observarea defectelor specifice procesului FDM, precum warping și spaghetti. Sistemul dezvoltat integrează funcții de raportare experimentală, captură snapshot și generare automată de rapoarte în format JSON și TXT, contribuind la creșterea trasabilității procesului de fabricație.

Rezultatele experimentale demonstrează că soluția propusă permite monitorizarea continuă a procesului FDM și corelarea defectelor observate cu parametrii de proces monitorizați în timp real.