Oct 28th, 8:00 AM - Oct 29th, 6:00 PM

International Conference on Mechatronic

University for Business and Technology - UBT

Oct 28th, 12:00 AM - Oct 29, 12:00 AM

International Conference on Mechatronic

University for Business and Technology - UBT

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12th UBT ANNUAL INTERNATIONAL CONFERENCE

INTERNATIONAL CONFERENCE ON MECHATRONICS, SYSTEM ENGINEERING AND ROBOTICS

28-29

OCTOBER

UBT Innovation Campus

Proceedings of the 12th Annual International Conference on Mechatronics, System Engineering and Robotics

Edited by

Edmond Hajrizi

Conference Book of Proceedings International Conference Pristina

ISBN 978-9951-982-09-2

International Conference on Business, Technology and Innovation Pristina, 28-29
Editor: Edmond Hajrizi

Publisher, UBT

Editor Speech of IC - BTI

International Conference is the 12th international interdisciplinary peer reviewed conference which publishes works of the scientists as well as practitioners in the area where UBT is active in Education, Research and Development. The UBT aims to implement an integrated strategy to establish itself as an internationally competitive, research-intensive institution, committed to the transfer of knowledge and the provision of a world-class education to the most talented students from all backgrounds. It is delivering different courses in science, management and technology. This year we celebrate the 21th Years Anniversary. The main perspective of the conference is to connect scientists and practitioners from different disciplines in the same place and make them be aware of the recent advancements in different research fields, and provide them with a unique forum to share their experiences. It is also the place to support the new academic staff for doing research and publish their work in international standard level. This conference consists of sub conferences in different fields: - Management, Business and Economics - Humanities and Social Sciences (Law, Political Sciences, Media and Communications) - Computer Science and Information Systems - Mechatronics, Robotics, Energy and Systems Engineering - Architecture, Integrated Design, Spatial Planning, Civil Engineering and Infrastructure - Life Sciences and Technologies (Medicine, Nursing, Pharmaceutical Sciences, Phycology, Dentistry, and Food Science),- Art Disciplines (Integrated Design, Music, Fashion, and Art). This conference is the major scientific event of the UBT. It is organizing annually and always in cooperation with the partner universities from the region and Europe. In this case as partner universities are: University of Tirana – Faculty of Economics, University of Korca. As professional partners in this conference are: Kosovo Association for Control, Automation and Systems Engineering (KA – CASE), Kosovo Association for Modeling and Simulation (KA – SIM), Quality Kosovo, Kosovo Association for Management. This conference is sponsored by EUROSIM - The European Association of Simulation. We have to thank all Authors, partners, sponsors and also the conference organizing team making this event a real international scientific event. This year we have more application, participants and publication than last year.

Congratulation!

Edmond Hajrizi, Rector of UBT and Chair of IC – BTI 2023

Content

Available Power of Arduino Mega 2560 without Recourse to extern Supply

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Abstract. The microcontroller family Arduino is getting more popular nowadays because of its practical handling and integrity to other systems. During conducting an experiment of controlling a humanoid robot of the type Robotis Bioloid not with its original microcontroller but with an Arduino Mega 2560 instead the power limits of it were found.

Keywords: Arduino Mega 2560, Power Limitation, Current Supply

Introduction

A humanoid robot is a robot with its overall appearance based on that of the human body. Perception, processing and action are embodied in a recognizably anthropomorphic form in order to emulate some subset of the physical, cognitive and social dimensions of the human body and experience. In general humanoid robots have a torso with a head, two arms and two legs, although some forms of humanoid robots may model only part of the body, for example, from the waist up. Some humanoid robots may also have a 'face', with 'eyes'and 'mouth'. The definition of a humanoid is as simple as "having human characteristics."

There are a multiple of companies producing humanoid robots for educational or entertainment purposes. Robotis is one of them. We worked mainly with Bioloid Comprehensive type of robot of them during this paper.

Each humanoid robot has its microcontroller unit to be able to manipulate the servos and manage other staff. The main goal was to control the robot with a common open source microcontroller which could be get for a reasonable price. The decision was an Arduino Mega 2560.

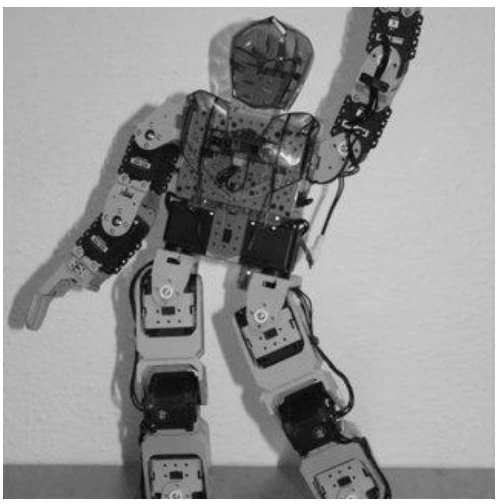

Fig. 1. Robotis Bioloid kit (Source: Robotis, 2022)

Fig. 2. Arduino Mega 2560 microcontroller (Source:https://www.arduino.cc/en/uploads/Main/ArduinoMega.jpg)

Tests

Our humanoid robot has 18 servo motors in total. Each servo is able to be moved independently in a given range. So starting our experiments every servo was able to be moved individually with the help of the Arduino controller.

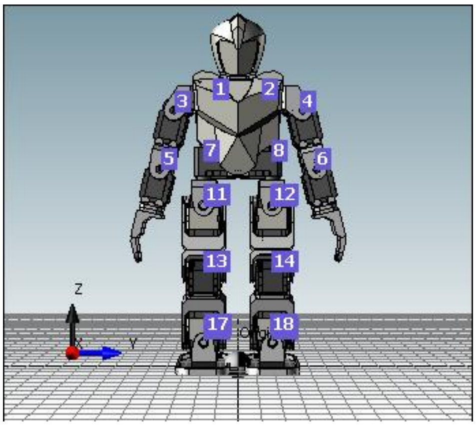

Fig. 3. All DOFs of our robot (Source: Robotis, 2022)

The servo motors used are of the type Dynamixel AX-12 which can also be purchased seperately to fulfill common tasks. The data sheet of it is available in Table 1.

Table 1. Specifications of Dynamixel AX-12 servo motors .

Model Name		AX-12A
MCU		-
	Min. [V]	9.0
Input Voltage	Recommended [V]	11.1
	Max. [V]	12.0
	Voltage [V]	12.0
Performance Characteristics	Stall Torque [N·m]	1.50
	Stall Current [A]	1.5

Continuous Operation	No Load Speed [rpm]	59.0
	No Load Current [A]	0.14
	Voltage [V]	-
	Torque [N·m]	-
	Speed [rpm]	-
	Current [A]	-
Resolution	Resolution [deg/pulse]	0.2930
	Step [pulse/rev]	1
	Angle [degree]	300
Position Sensor		Potentiometer
Operating Temperature	Min. [°C]	-5
	Max. [°C]	70
Motor		Cored
Baud Rate	Min. [bps]	7,843
	Max. [bps]	1,000,000
Control Algorithm		Compliance
Gear Type		Spur
Gear Material		Engineering Plastic
Case Material		Engineering Plastic
Dimensions (WxHxD) [mm]		32 X 50 X 40
Dimensions (WxHxD) [inch]		1.26 X 1.97 X 1.57
Weight [g]		55.00
Weight [oz]		1.93
Gear Ratio		254 : 1
Command Signal		Digital Packet
Protocol Type		Half duplex Asynchronous Serial Communication (8bit, 1stop, No Parity)
Link (Physical)		TTL Level Multi Drop Bus
ID		0 ~ 253
Feedback		Position, Temperature, Load, Input Voltage, etc
Protocol Type		Protocol 1.0
Operating Mode / Angle		Wheel Mode : Endless turn Joint Mode : 300 [deg]
Output [W]		-
Standby Current [mA]		50

After the first tries of controlling the servos the goal was to move the servos in sequence, so a human like behaviour would be imitated . Moving one and also two servos worked without difficulties but at the same time it was noticed that the power supply part of Arduino board was overheated. When a third servo was added to the sequence the robot began not to react at all first and trying it several times the code could not be loaded from computer to the Arduino board anymore.Looking for the reason it was realized that the bootloader of the microcontroller could be burnt. A second and also third new Arduino microcontroller board were damaged in the same way. So there should some incompatibilities between the robot and the microcontroller. A very decent idea was also that the Arduino board can not provide enough current to supply the servos. The Dynamixel AX-12A servos of the robot need a current of 1,5A at a voltage of 12V which results in a needed power of 18W. Obviously this could not be delivered by our Arduino controller.

Summary and Outlook

The microcontrollers of Arduino face increasing popularity all over the world. The tests done showed us that an external current source seems to be more rational to use if one needs more than, in our case, 2x18 Watt of power. The controller itself can only deliver small currents which yields small total powers.

References (in Basic)

Arduino website : https://www.arduino.cc/en/uploads/Main/ArduinoMega.jpg
Robotis website: BIOLOID Premium Advanced Educational Robot Kit (robotis.us)

Robotis website: https://www.robotis.us/dynamixel-ax-12a/

A Prototype Car Display Control System with Motion and Seat Belt Sensing

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Abstract. The article presents a prototype for a car screen lock system that promotes seat belt use while also regulating screen access. The system incorporates motion detection, seat belt monitoring, sound alarms, and screen lock function, and serves as a conceptual model for potential integration into real-world automotive systems. The prototype simulates automotive using motion detection and continuously examines seat belt fastening status, promoting the use of seat belts as an important safety measure. Built-in auditory alerts give the driver with aurel reminders, stressing safety compliance. When the car is moving and the seat belt is fastened, the screen is unobstructed, otherwise is locked with an advisory message. The significance of this approach rests in reducing the significant risks associated with noncompliance. Failure to wear a seat belt not only raises the chance of serious injury in a crash but also encourages distractions such as mobile phone use, missing navigation directions, and ignoring vital notifications, jeopardizing driver focus and overall road safety. The research as a future path includes seamless integration with genuine automobile sensors and displays while following safety rules to provide a practical and safe in-vehicle display control system.

Keywords: Screen lock system, automotive, seat belt security, display control, sensors, microcontroller, driver safety.

Introduction

Prioritizing road safety has never been more important in today's changing automotive scene. The potential for distraction within the vehicle has expanded rapidly as technology progresses, creating a compelling need for creative solutions that not only promote safe driving practices but also limit risks associated with noncompliance. This article focuses on creating a cutting-edge car display control system called "Drive Rules" which uses motion detection and seat belt sensing to encourage responsible driving behavior.

"Drive Rules" is primarily intended to address two of the most serious safety concerns in modern vehicles: seat belt usage and screen distractions. Seat belts are the first line of defense against injuries in the case of an accident, and their effective use is an unavoidable safety precaution. However, there are times when drivers and passengers fail to secure their seat belts, putting themselves and others on the road at risk.

The use of in-car displays is the second main source of vary. While these displays provide useful information and pleasure, they can also be sources of distraction, diverting a driver's focus away from the road. Critical Navigation directions, important notifications, and even phone calls and messages frequently compete for drivers' attention, posing serious safety risks.

"Drive Rules" addresses these difficulties by combining motion detection and seat belt sensor technology. It monitors the vehicle's movements, ensuring that the display is only visible when the vehicle is moving. Simultaneously, the device monitors seat belt usage and prompts individuals to buckle their seat belts.

Literature review

The use of modern technologies to obtain information in real time is beneficial for drivers and passengers. These offer several advantages, but the biggest disadvantage is that drivers and passengers may lose focus if they are reminded of this information at the same time they neglect the rules of wearing seat belts [1]. Perhaps the designs of the screens and where they are placed will help, for example, positioning them with your head up promotes a level of concentration even when driving [2].

Allowing navigation systems and the growth of information acquisition has its benefits, but this information may also take steps in the sense of safety, such as speed adjustment, and so on [3]. Perhaps the major need of drivers and passengers is to allow the quality of services while driving, with 1045 drivers polled indicating that the quality of services is paramount [4].

The presented paper does not deal with the study of seat belt placement detection because there are several detection techniques and methodologies, mostly using modern technology such as image processing and the application of various sensors. While traveling primarily on highways, drivers are primarily concerned with speed and reaction time is reduced; this scenario leads us to believe that there must be methods of detecting the deployment of the safety belt like in the study's examples [5].

Many scientific studies have shown that not wearing or properly wearing a seat belt increases the number of fatalities. As in the case [6], the results reveal that the increase in the number of fatalities is likewise due to not wearing a seat belt.

Furthermore, regulations on the installation and use of seat belts should be devised and detailed, and it should be made unique for the first time in the continent and the entire world because people are moving much more nowadays [7], the framework must be developed to push drivers and passengers to make decisions, particularly in public transportation. Based on study findings [8], it can be shown that people's confidence in the usage and non-use of seat belts is not very great.

Based on experience, science, and the development of legislation governing the use of seat belts, it is apparent that their use by drivers and passengers reduces the likelihood of fatal accidents. It has been confirmed via a review of the literature that regardless of the complaint, such as the syndrome of not wearing a belt, its use must be mandated both legally and due to technological restrictions.

Referring [9] to the authors who searched the seat belt-related literature on all the publishing platforms, including PubMed, Scopus, Web of Science, etc. From this, we can observe that there are numerous works, but this does not imply that the field is fully explored; in fact, we may still strengthen it with the use of current technologies. In the article [10], infrared cameras were used, as well as monitoring with the Driving Monitoring System and Occupant Monitoring System -OPS, which constantly follow the wearing of the seat belt as well as others related to the condition of the driver, especially eye fatigue. his eye, as monitoring in a cabinet camera[11].

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Problem definition

The research attempts to address the safety factors that provide additional risks to drivers and passengers due to the high safety of distraction control.

Research question: What is the effectiveness of in-car display systems in reducing vehicle crashes and encouraging the use of seatbelts?

Hypothesis: Our theory is that the installation of a car screen lock system will encourage the use of seat belts and decrease instances of distracted drivers.

The system will work as a conceptual model for the integration of the actual vehicle and detect potential movement, seat belt monitoring, voice alarms, and screen locks. The screen remains clear when the car is moving and the seat belt is buckled; if not, a warning will appear and the screen will lock. The reduction of an issue about inconsistency highlights the significance of this section. In addition to increasing the risk of injury in an accident, not wearing a seat belt increases the risk of distracted driving, lost navigation, and disregard for traffic

Methodology

A systematic method was used in the creation of “DriveRules” car display control system to assure the successful integration of motion detection, seat belt sensing, voice alerts, and display control functions. The techniques are divided into major stages, each of which is critical to the overall operation and safety of the system.

The first phase entailed a thorough examination of the requirements. Gathered information from surveys, current literature, and talks with vehicle safety specialists. This process enabled to identification of the unique issues associated with control display, seat belt monitoring, and distraction prevention while driving.

Following a requirements analysis, carefully choose the essential hardware component, which includes Raspberry Pi Pico, camera module, and piezo buzzer. These components served as the system foundation. Furthermore, because of its versatility and interoperability with the Raspberry Pi environment, python is for major programming language.

Motion detection was accomplished by carefully placing motion sensors within the vehicle to properly evaluate its movement. Seat belt detection methods were built using a combination of camera modules and pressure sensors, allowing real-time monitoring of seat belt usage. To ensure accurate measurements, these components were calibrated and configured.

Voice alarms are added to increase safety, this included the development of voice recognition and synthesis capabilities, which allowed the system to provide audio reminders to the driver in the event of seat belt noncompliance or when the car was not in motion. The display control logic was painstakingly constructed, with algorithms dictating screen accessibility based on motion and seat belt status.

A critical of the system design was user interaction. It designed a user-friendly interface with buttons, indicators, and display messages that allowed drivers to accept audio alarms and renter displays when safety conditions were met. To assure the system's reliability, accuracy, and safety compliance, rigorous testing and validation procedures were carried out utilizing predetermined test scenarios and environments.

In the future “Driverules”, offer the potential for scalability and integration with real-world vehicle systems. These future paths entail more hardware advancement as well as conformity with industry standards. Throughout the project development, ethical concerns about privacy, data collection, and user consent were paramount.

The “Drive rules” car display system was developed using this methodology, setting the groundwork for a comprehensive and safety-conscious solution to seat belt compliance and in-car display distraction, improving road safety.

Results

The results are given as predicted system behavior and user interaction in the absence of a fully built system. The following intended outcomes can be expressed using the code and methodology:

Car Status, when you hit the Start Car button, the system replicates the transition of the car from stationary to a driving condition. The car status label is updated as a result of “Fig 1” and “Fig 2”.

The fasten seat belt button simulates attaching the seat belt, the seat belt status label indicates whether or not is secured. When the seat belts have been tightened and the Fasten Seat Belt button is hit, "Fig. 3" immediately sends you a "Have a nice trip" message.

If the seat belt is not tightened or the car is not moving the “Voice Alarm” button activates a simulated voice alarm message to encourage the users to fasten the seat belt and keep the car moving so that the display can be accessed.

The “Control Display” button illustrates display access control. The display becomes available when the car is not in motion and the seat belt is secured. Otherwise, the display stays blocked, and the apps reflect this.

The user experience is expected to correlate with the “Drive Rules” system’s stated safety objectives. Users will be able to engage with the app’s graphical interface to mimic automobile movements, fasten seat belts, receive voice alarms as reminders, and see how seat belt compliance affects display access.

It is critical to recognize the code described here is a simplified prototype that does not communicate with real automotive sensors or hardware. The integration of these components would determine the actual behavior and consequences. Interfacing with authentic automotive systems, adding voice recognition and synthetic ca[abilitites, and resolving safety rules and ethical considerations for a fully functional “Drive Rules” system are all possible in future approaches.

In summary, while the given results are based on a conceptual prototype, they provide insight into how the “Drive Rules” system is planned to operate and interact with users in order to promote seat belt compliance and display control for improved road safety.

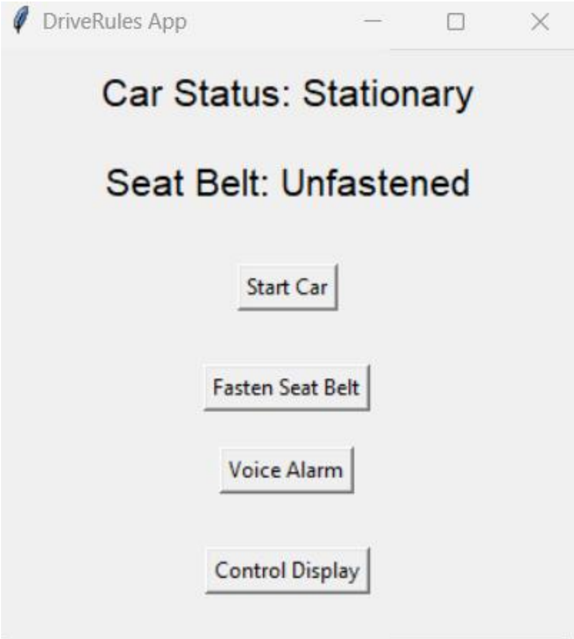

Figure 1. Drive Rules App

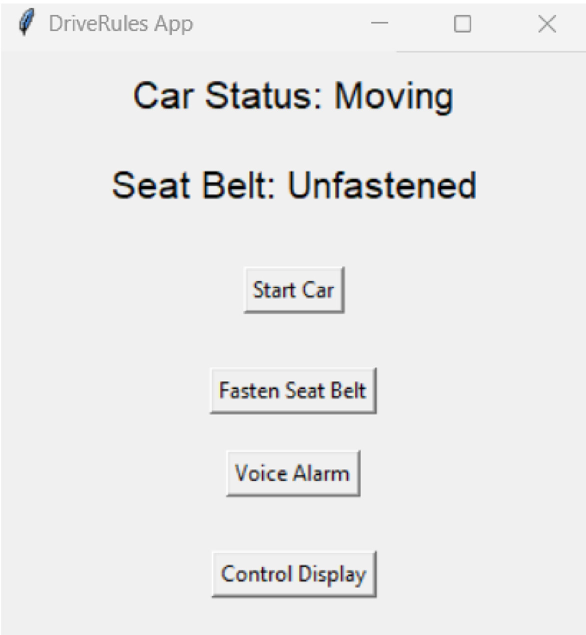

Figure 2. After hitting "Start Car"

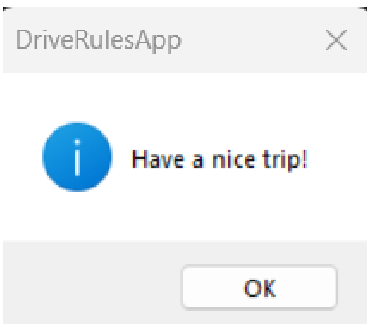

Figure 3. After hitting Fasten Seat Belt button

Discussion

In the research paper's discussion, we can highlight the significance of the results obtained from the predicted system behavior and user interaction. The code and methodology allowed us to achieve several intended outcomes. Firstly, the "Car Status" feature accurately simulates the transition of the car from stationary to a driving condition when the "Start Car" button is pressed. The car status label dynamically updates based on the simulated actions represented in "Fig 1" and "Fig 2”. Secondly, the "Fasten Seat Belt" button replicates the process of attaching the seat belt, and the seat belt status label indicates whether it is secured or not. When the seat belts are tightened and the "Fasten Seat Belt" button is pressed, "Fig. 3" promptly displays a "Have a nice trip" message. Moreover, if the seat belt is not fastened or the car is not in motion, the "Voice Alarm" button activates a simulated voice alarm message to remind users to fasten their seat belts and keep the car moving in order to access the display. The "Control Display" button demonstrates access control to the display. The display becomes available only when the car is stationary and the seat belt is secured. Otherwise, the display remains blocked, and the apps reflect this restriction. The user experience aligns with the safety objectives of the "Drive Rules" system. Users can interact with the graphical interface to mimic real automobile movements, fasten seat belts, receive voice alarms as reminders, and observe how seat belt compliance impacts display access. However, it is crucial to acknowledge that the described code represents a simplified prototype that does not integrate with actual automotive sensors or hardware. The inclusion of these components would determine the system's actual behavior and consequences. Future approaches could involve interfacing with authentic automotive systems, incorporating voice recognition and synthetic capabilities, and addressing safety rules and ethical considerations to develop a fully functional "Drive Rules" system. In conclusion, while the obtained results are based on a simulated environment, they provide valuable insights into the potential functionality and user experience of the "Drive Rules" system. Future developments can explore further enhancements and address real-world integration challenges.

Future work

The seamless integration of “Drive Rules” system with actual vehicle hardware and sensors is a vital avenue for future study. This would allow the system to interact with real-world vehicle data, such as speed sensors and seat belt sensors, improving accuracy and effectiveness. Integration of the technology with the vehicle's existing display infrastructure would also create more authentic user experience.

Future work can concentrate on implementing improved voice-recognized and synthetic technologies. These improvements would allow the system to interpret the driver’s spoken commands and offer clear and context-aware voice alarms. Improved voice interaction capabilities would make the system more accessible and user-friendly.

Future development should emphasize rigorous testing and validation to assure widespread adoption and compliance with safety requirements. It is critical to test the system's safety features, such as ensuring that voice alarms do not generate distractions. Compliance with industry-specific safety standards and regulatory laws is also critical for the system’s deployment in real-world cars.

The “Drive Rules: systems data can provide significant insights into driver behavior and safety compliance. Implementing data analytics tools to monitor user interactions, assess compliance patterns, and provide individualized safety advice could be part of future development.

Appendix

```
import tkinter as tk

from tkinter import messagebox


class DriveRulesApp:

    def __init__(self, root):

        self.root = root

        self.root.title("DriveRules App")
```

```
        self.car_moving = False
        self.seat_belt_fastened = False
        self.display_blocked = True

        self.create_widgets()

    def create_widgets(self):
        self.car_status_label = tk.Label(self.root, text="Car Status: Stationary", font=("Helvetica", 16))
        self.car_status_label.pack(pady=10)

        self.seat_belt_label = tk.Label(self.root, text="Seat Belt: Unfastened", font=("Helvetica", 16))
        self.seat_belt_label.pack(pady=10)

        self.start_car_button = tk.Button(self.root, text="Start Car", command=self.start_car)
        self.start_car_button.pack(pady=20)

        self.fasten_seat_belt_button = tk.Button(self.root, text="Fasten Seat Belt", command=self.fasten_seat_belt)
        self.fasten_seat_belt_button.pack(pady=10)

        self.voice_alarm_button = tk.Button(self.root, text="Voice Alarm", command=self.trigger_voice_alarm)
        self.voice_alarm_button.pack(pady=10)

        self.display_control_button = tk.Button(self.root, text="Control Display", command=self.toggle_display)
        self.display_control_button.pack(pady=20)

    def start_car(self):
        self.car_moving = True
        self.car_status_label.config(text="Car Status: Moving")

    def fasten_seat_belt(self):
        self.seat_belt_fastened = True
        self.seat_belt_label.config(text="Seat Belt: Fastened")

        # Check if the car is moving
        if self.car_moving:
            self.root.destroy()  # Close the window
            messagebox.showinfo("DriveRulesApp", "Have a nice trip!")

    def trigger_voice_alarm(self):
        if not self.seat_belt_fastened or not self.car_moving:
            print("Voice Alarm: Please fasten your seat belt and ensure the car is moving to use the display.")

    def toggle_display(self):
```

```
        if self.car_moving and self.seat_belt_fastened:
            self.display_blocked = not self.display_blocked
            self.root.title("DriveSafe App - Display Accessible" if not self.display_blocked
                    else "DriveSafe App - Display Blocked")


if __name__ == "__main__":
    root = tk.Tk()
    app = DriveRulesApp(root)
    root.mainloop()
```

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Application of 3D Technology in Accessories and Fashion Design

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Abstract. This article delves into 3D Printing's multifaceted applications in fashion, emphasizing its potential for intricate parametric designs and personalized clothing, reshaping the industry. The article includes a practical case study demonstrating iLogic's efficient use to automate part attribute determination and conduct comprehensive stress analysis on a 3D-printed keychain.

Keywords: 3D Printing Technology, Parametric Design, Inkjet Printing, Fashion and Textile, Accessories

1 Introduction

3D Printing, a CAD/CAM technology, creates objects layer by layer from digital models, offering cost-effective and sustainable production. It involves pre-processing (design and layering) and post-processing (finishing) stages, utilizing materials like PET, PA, ABS, PLA, and methods such as SLA and FDM in textile and fashion manufacturing [1].

Parametric design, driven by digital technology, is gaining popularity across various fields, including architecture, fashion, and industrial design. Combining parametric design with 3D printing is recognized as a powerful method for creating intricate structures and fostering creativity. Many studies have successfully applied 3D printing to realize parametric designs in sculptures, apparel, and fashion accessories [2].

The integration of iLogic into Autodesk Inventor elevates the realm of 3D modeling by introducing rule-based computational capabilities. This article delves into a practical application of iLogic, showcasing its ability to imbue designs with sophisticated intent. In focus is the management of "Gjeresia," a crucial parameter; iLogic ensures it falls within specified bounds, generating correction messages when necessary. Furthermore, this study examines the structural aspects of a 3D-printed keychain, crafted from PLA Plastic with precise material properties. Using Autodesk Inventor 2022, Finite Element Analysis reveals critical insights into stress distribution, displacement, and safety factors, ultimately ensuring the keychain's robustness and reliability.

2 Literature Review

3D printing, or additive manufacturing, is a method of creating objects layer by layer using digital models and various materials. This technology offers sustainability and cost advantages over traditional manufacturing methods. Chakraborty et al. [1] introduce a model known as Fused Deposition Modeling for 3D printing in textile and fashion applications. The article thoroughly explains the 3D printing process, comprising pre-processing and post-processing phases.

Jeong et al. [2] emphasize the increasing importance of 3D printing in the fashion industry, highlighting its ability to enable intricate parametric designs. They discuss the fusion of design and programming, the need for education in 3D printing-based fashion design, and the development of various 3D-printed fashion products. Additionally, they showcase examples of parametric fashion designs inspired by nature and organic structures, illustrating the creative possibilities arising from the integration of technology into modern fashion.

Fanglan et al. [3] explore how the combination of 3D printed clothing and big data analysis is transforming the fashion landscape. They describe how designers utilize a comprehensive database of 3D printed elements to create personalized clothing, aligning with consumer preferences and shaping fashion trends. The study also explores the expansion of 3D printing into accessories such as bags, shoes, and hoodies, highlighting both style and functionality. Furthermore, the authors emphasize the potential of personalized advanced customization, guided by big data insights, to produce clothing perfectly tailored to individual preferences and body shapes, influencing the future of the fashion industry.

Chakraborty et al. [4] delve into inkjet printing as a popular 3D printing technique for creating objects through layer-by-layer material deposition. They explain the thermal drop on demand (DOD) ink jetting method, involving the use of heat to create bubbles in liquid ink, propelling ink droplets through a microscopic orifice in the print head. The materials used in inkjet printing, including reactive diluents and support materials, are discussed, emphasizing their thermal stability and ease of removal. The inkjet printing process involves depositing building and support materials layer by layer, typically using photopolymers. The benefits of this technique, such as not requiring volatile solvents, are highlighted. The paper also mentions applications of inkjet printing in fashion and textiles, including the creation of garments and accessories with textured and flexible features, as well as its use in electronic textiles for printing sensors or circuits on fabric.

Shahrubudin et al. [5] explore how 3D printing is reshaping the retail industry, with a focus on shoes, jewelry, consumer goods, and clothing production. Major companies like Nike, New Balance, and Adidas are actively mass-producing 3D printed shoes for athletes and custom shoe enthusiasts. Beyond footwear, 3D printing is revolutionizing fashion design by enabling the creation of unique shapes without the need for molds, simplifying garment and ornament production. This technology also extends to leather goods and accessories, including jewelry and watches. Retailers and designers are keen on offering personalized products, capitalizing on the advantages of 3D printing such as customized fit, cost efficiency in the supply chain, and rapid small-scale production.

In their study, Zangheri et al. [6] provide details on the fabrication of a 3D-printed smartphone accessory and LFIA cartridge using a Makerbot Replicator 2X printer. Specifically designed for a Samsung Galaxy SII Plus smartphone, this accessory incorporates a lens and housing to accommodate the LFIA cartridge, effectively minimizing ambient light interference. The LFIA cartridge is a complex assembly with multiple components, requiring it to be printed in two separate parts and subsequently assembled. The authors also investigate the effectiveness of the smartphone's camera compared to a traditional laboratory imaging instrument, the Night OWL LB 981 luminograph, with a focus on detecting Chemiluminescence (CL) signals from LFIA membranes. In summary, this study highlights the development of 3D-printed accessories aimed at enhancing smartphone-based LFIA assays and presents a comparative evaluation of their performance against a laboratory-grade instrument.

Parametric design (PD) means the use of a CAD system to automatically modify a design as the values of the parameter change and to make corresponding changes to the CAD model during the design process [7]. Given a design problem, the requirements are transformed into a set of parameters and their constraints are also represented via a series of mathematical or logical relations in a hierarchy manner, capturing the product’s behaviors and the structures [8]. As the design progresses further, parameters are introduced describing the dimensions of the object and potentially physical properties to be used for its construction. Therefore, PD offers potentials in quickly design solution generation in terms of the requirements and also maintains the design history steps to create variable CAD models instead of keeping only the one outcome model [9].

Shabani et al. [10] discuss the diverse applications of 3D digital measurement technology, covering dimensions, displacements, and deformations of various parts. They emphasize the technology's relevance in fields such as additive manufacturing and its potential for integration with advanced manufacturing processes through a digital chain. They highlight the primary use of 3D digital measurement for dimensional checks, especially in complex parts, and provide visual examples of these applications. Additionally, they mention special requirements for dynamic measurements, exemplified by the measurement of 3D vibration displacement in a car door. Another important aspect discussed is the measurement of part deformations, with examples of 3D deformation analysis and testing of a 3D printed suitcase handle button.

3 Case Study

In this section, I've described a code designed to determine part color, material, and other variables based on user input values. Additionally, it conducts stress analysis on the designed part, which has also been 3D printed.

3.1 iLogic of the Designed Part

iLogic extends the computational capabilities within Inventor to include rules.

These rules work along with the parameter update mechanism of Inventor, and allow

us to include much more sophisticated design intent into our models. A written code manages "Gjeresia": below 60, it's set to 60 with a correction message; above 75, it's set to 75 with a correction message. Different values are assigned to properties like "Gjatesia," "Trashesia," "Shkronjat," "Diametri," "Material," and "Part Color" based on "Gjeresia" ranges (60-65, 66-70, 71-75).

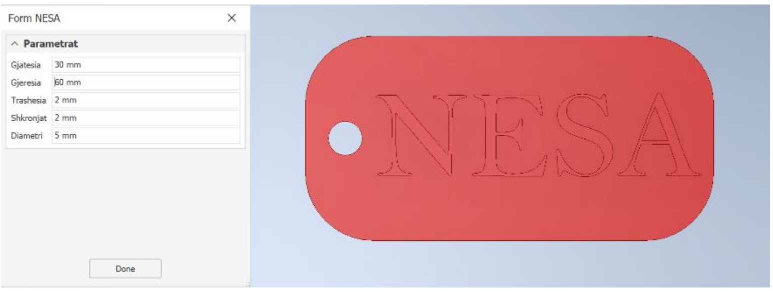

Fig. 1. The result we will have when the “Gjeresia” values are greater than or equal to 60 and less than or equal to 65 (Material: ABS Plastic, Color: Red)

Fig. 2. The result we will have when the “Gjeresia” values are greater than 65 and less than or equal to 70 (Material: PLA Plastic, Color: Dark Grey)

Fig. 3. The result we will have when the “Gjeresia” values are greater than 70 and less than or equal to 75 (Material: Aluminum 6061, Color: Silver)

3.2 Stress Analysis

To analyze "Stress Analysis," Autodesk Inventor 2022 software was used. In the drawing, we can see a keychain, which was 3D printed using PLA Plastic material with the following specifications: Behavior: Isotropic, Young's Modulus: 2.91 GPa, Density: 1.29 g/(cm³), Yield Strength: 38.00 MPa, Tensile Strength: 47.20 MPa.

For Finite Element Analysis, it was necessary to fix a surface. In this case, the base surface was fixed, and a force in the direction of the Fx axis with a value of 15 N was applied. It's important to note that this keychain will never bear a weight greater than 1 kg (9,8 N), but for analysis and safety considerations, a higher value was considered. From the conducted analyses, the following observations can be made:

Von Mises Stress: The minimum stress in the part is 0 MPa, while the maximum stress in the part is 1.104 MPa (Fig. 4).

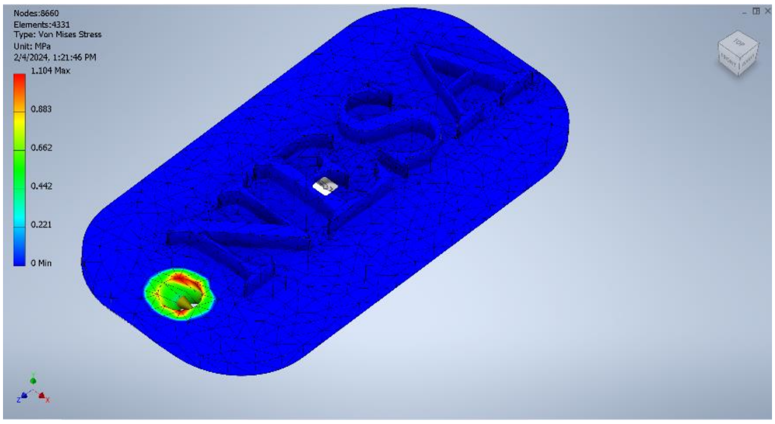

Fig. 4. The minimum and the maximum stress on the part (1.104 MPa – Max and 0 MPa – min)

Displacement: The maximum displacement in millimeters is approximately 3.9e-04 mm, which is nearly negligible in practical terms (Fig. 5).

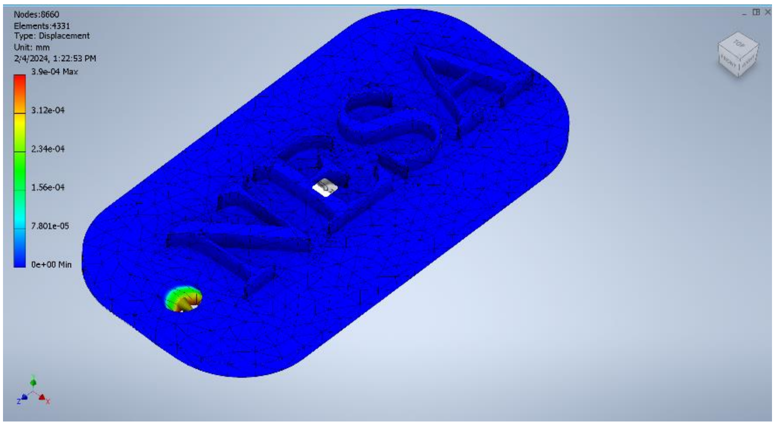

Fig. 5. Displacement (3.9e-04 mm – Max)

Safety Factor: The maximum safety factor is 15, while the calculated safety factor is approximately 3.5. This indicates that the model is approximately 3.5 times more stable than the current applied load (Fig. 6).

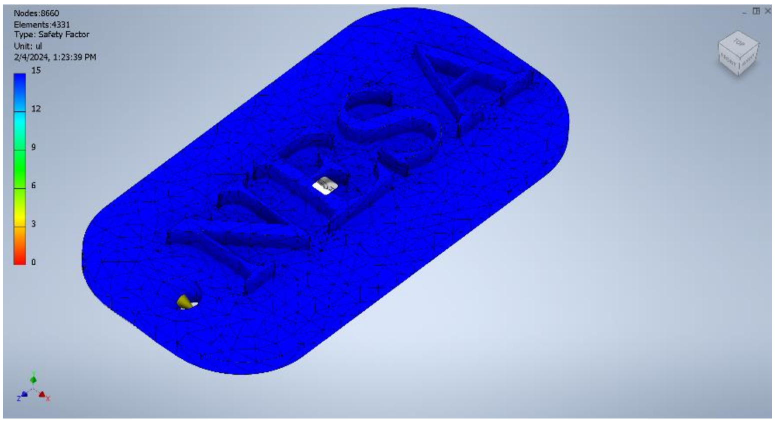

Fig. 6. Safety Factor

As mentioned earlier, this keychain has been 3D printed (Fig. 7).

Fig. 7. 3D Print of the Keychain

4 Conclusion

This article explores the various applications and implications of 3D printing technology in fields such as fashion, manufacturing, and digital measurement. It also delves into the practical implementation of 3D printing using iLogic in Autodesk Inventor, showcasing its ability to automate part attribute determination based on user input, which will enable users to print their own designs. The integration of iLogic in 3D printing processes is a significant step towards making 3D printing more accessible and user-friendly, and it has the potential to revolutionize the way we design and manufacture products. The stress analysis on the 3D-printed keychain provides crucial insights into structural integrity and safety. The results indicate a well-designed and stable model, with Von Mises stress, displacement, and safety factor analyses offering valuable information for ensuring reliability in 3D-printed objects.

Appendix A. Parameters in iLogic. Gjerësia-Width, Gjatësia-Height, Trshësia-Thickness of Base, Shkronjat-Thickness of Letters, Diametri-Diameter.

Acknowledgements. With appreciation, I extend my thanks to my engineer friend, Riza Mehmetaj, for his help in designing the part used in this research.

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Synchronized Communication used in Collaborative Humanoid Robots with Datacenter Applications

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Abstract. This manuscript is to describe a communication method used to operate data center related applications where multiple robots are required. In this configuration one of the robots is considered as the leader while the other one performs as a follower. The operations performed from the collective operation of the two robots aim to reach a coherence to allow applications that require multiple robots to be performed seamlessly. The development of this work was based on humanoid robots though it can be expanded to any robot platform based on a given application.

Keywords: Synchronized Robots, Robot Communication, Arbotix-M, XBee.

Introduction

Designing a datacenter with “human operator” brings various limitations. These limitations include environmental conditions such as temperature limits, power limits such as low voltages, safe materials, human approachable dimensions and human carriable weights. Without factoring human as the operator most of these limitations can be lifted, resulting in a more efficient design. Besides, computers can take advantage of lower temperature environment allowing them to operate at higher frequencies and more heat dissipation.

Using robots instead of human in datacenter can be rewarding due to the fact that robots can operate in a wide environmental condition in comparison to humans. Robots can carry heavy weights and can be designed to operate in any dimension without the human physiology limitation.

Changing the current design of datacenters from a human centric to a robot centric model requires years of development and experimentations. Considering humanoid robots as the most human like robots, the gap between human dexterities and capabilities versus a robotic analogue can be minimized.

Most of the current datacenter tasks can benefit from a collaborative operation of multiple robots. The robots operating in a collaborative task require to be synchronized in order to perform a given tasks coherently.

Method

In this work, two humanoid robots from Robotis (Bioloid) have been used to demonstrate the capabilities of humanoid based synchronized collaborative operation. One of the robots performs as the lead while the other one is the follow. The leader robot generates the required motions for itself as well as the follower robot. In order to achieve the described scheme, both robots' main controller has been redesigned based on the open-source Arduino based Arbotix-M controller shown in figure 1, preserving the AX-12A servo motors and the humanoid mechanism from the Robotis Bioloid robot shown in figure 2.

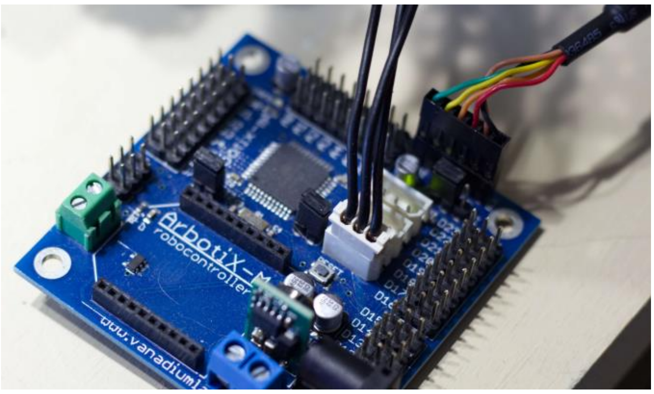

Fig. 1. Arbotix-M opensource robot controller [1]

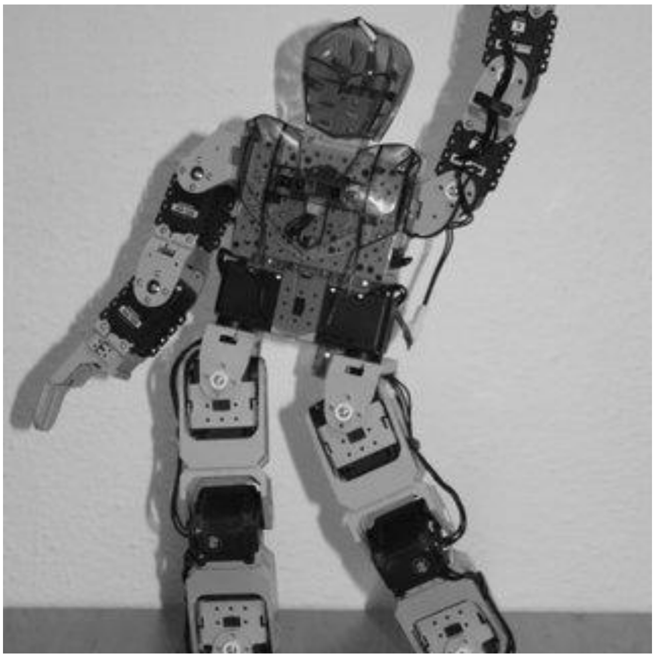

Fig. 2. Bioloid humanoid robot [2]

The communication between the two robots is performed using a pair of XBee 1mW modules shown in figure 3. The two modules use a 802.15.4 stack to establish a simple serial communication with a 250kbps max datarate, sufficinet for this application. The communication package includes the position angles of each servo motor for the follower robot followed by a CRC-checksum. Upon receiving the data package the follower robot calculates the checksum and compares it with received checksum to assure the accuracy of the incoming data.

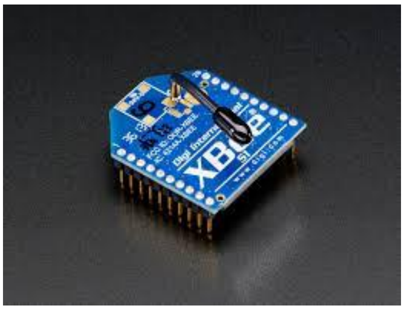

Fig. 3. XBee module [3]

Upon checking the accuracy of the incoming data, the controller will execute the position angles. Once the position angles are executed successfully the follower controller will send an acknowledgement signal to the leaders controller ensuing to the next time stamp.

Experiments

The two robots are trying to walk a straight path, holding a stick from the two ends (each robot holds one end). In order to perform this task successfully, both robots need to perform synchronized, temporally and specially.

Results

The experiment was performed successfully as both robots operated synchronized and the task was achieved.

Conclusion

Performing synchronized collaborative tasks using multiple robots has the potential to be used as an alternative for human centric applications. The tests are executed, utilizing simple humanoid robots regarding the cost orientation of the project after the main focus should be the communication issue. With robots of any kind and not only human-like ones with heavy-duty power elements, various tasks in a data center are potentially achievable.

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Optimizing Welding Parameters of Submerged Arc Welding based on Hardness in S235JR Construction Steel

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Abstract

This paper details the influence of the welding parameters of submerged arc welding in the hardness of welded joint of S235JR construction steel. The planned experiment work is conducted in the semiautomatic submerged arc welding machine and the contribution of each factor has been considering, such as: (intensity, voltage, trolley welding speed, diameter of the wire, wire speed, cooling speed of the welded joint, OK Flux 1071, chemical properties of material and wire). The results of the present investigation indicate that the welding voltage, current intensity and environment of cooling of the welded joint are the most significant factors that controls the hardness of bead. Optimal results were obtained by using the tension of 37 V, intensity of 350 A at a trolley speed of 6.0 mm/s and wire diameter 2.4 mm.

Keywords: S235 Steel, Submerged Arc Welding, Welding Parameters, Weld bead, Hardness.

1 Introduction

Mechanical properties and reliability of weld joint were subject of different authors [1, 2, 3, 4]. The energy is devoted also on effect of microdefects under cyclic load of weld joint [5] and in optimization of weldbead geometrical parameters during Submerged Arc Welding (SAW) [6] where is revealed that SAW largely depend upon the weld bead geometrical parameters such as weld width, depth of penetration and reinforcement height. Prediction of SAW process parameters is a very complex process. Many investigators have tried to correlate the process parameters with the weld bead which geometrical shape characteristics result into high strength and high quality welds [6]. In recent years, research and development efforts have focused on refining SAW techniques to meet the evolving demands of industries such as shipbuilding, construction, and heavy manufacturing. This review explores the advancements in SAW technology, including innovations in flux formulations, automation, and adaptive control systems, aiming to enhance weld quality, productivity, and overall process efficiency.

Furthermore, the article delves into the current applications of SAW, ranging from the fabrication of structural components to the manufacturing of pressure vessels and pipelines. Through a critical analysis of existing literature and case studies, this review aims to provide insights into the performance, challenges, and potential solutions associated with submerged arc welding.

As we navigate the intricacies of SAW, this article not only serves as a comprehensive resource for welding professionals, researchers, and academicians but also sets the stage for envisioning the future prospects of this indispensable welding technology. In an era of rapid technological evolution, understanding and advancing SAW capabilities hold the key to unlocking new frontiers in welding excellence and industrial progress.

This paper presents the details of an experimental work on S235JR steel (10mm thickness) using SAW process to yield desired quality of bead, in terms of beads geometry and hardness, as influenced by voltage (V), current(A), welding speed and diameter of wire which are varied at four different levels. Our aim of this investigation is that through measurements we have done to alleviate and propose different manufacturers which use S235JR steel as base material, proper selection of welding parameters depending on the level of strength that they want to reach or level of strength that they are required.

2 Materials and methods

Submerged arc welding (SAW) was used as welding process to prepare our testing specimens. SAW is normally operated in the automatic or mechanized mode, however, semi-automatic (hand-held) SAW guns with pressurized or gravity flux feed delivery are available. The process is normally limited to the flat or horizontal-fillet welding positions (although horizontal groove position welds have been done with a special arrangement to support the flux). Deposition rates approaching 45 kg/h (100 lb/h) have been reported this compares to ~5 kg/h (10 lb/h) (max) for shielded metal arc welding. Although currents ranging from 300 to 2000 A are commonly utilized, currents of up to 5000 A have also been used (multiple arcs). Single or multiple (2 to 5) electrode wire variations of the process exist. SAW strip-cladding utilizes a flat strip electrode (e.g. 60 mm wide x 0.5 mm thick). DC or AC power can be used, and combinations of DC and AC are common on multiple electrode systems. Constant voltage welding power supplies are most commonly used; however, constant current systems in combination with a voltage sensing wire-feeder are available [7]. SAW filler material usually is a standard wire as well as other special forms. This wire normally has a thickness of 1.6 mm to 6 mm (1/16 in. to 1/4 in.). In certain circumstances, twisted wire can be used to give the arc an oscillating movement. This helps fuse the toe of the weld to the base metal. The electrode composition depends upon the material being welded. Alloying elements may be added in the electrodes. Electrodes are available to weld mild steels, high carbon steels, low and special alloy steels, stainless steel and some of the nonferrous of copper and nickel. Electrodes are generally copper coated to prevent rusting and to increase their electrical conductivity. Electrodes are available in straight lengths and coils. Their diameters may be 1.6, 2.0, 2.4, 3, 4.0, 4.8, and 6.4 mm. The approximate value of currents to weld with 1.6, 3.2 and 6.4 mm diameter electrodes are 150–350, 250–800 and 650–1350 Amps respectively [8]. On figure below is shown submerged arc welding machine.

Fig 1. a) submerged arc welding machine

b) wire and OK Flux 1071 [7].

2.1 Base material, welding parameters, wire and dimensions of PLATE 5

Dimensions of plate P1, P2, P3, P4, P5 are described on table 1, while welding parameters are given on table 2.

Table 1. Dimensions of plate

Plate	*Thickness [mm]*	*Width [mm]*	*Length [mm]*
P1	10	80	320
P2	10	80	320
P3	10	80	320
P4	10	80	320
P5	10	80	320

Table 2. Welding parameters for each welding seam

Seam nr.	I [A]	U [V]	dw [mm]	t [s]	vw [mm/s]	vt [mm/s]
T5.1	400	42	2.4	50	6.0	6.0
T5.2	270	28	2.4	66.6	4.0	4.5
T5.3	310	32	2.4	60	5.3	5.0
T5.4	350	37	2.4	50	5.5	6.0

I- intesity, **U**- tension, $\mathbf{d_w}$ – diameter of wire, **t**- time of weld for a seam, $\boldsymbol{v_w}$*- speed of wire flow,* $\boldsymbol{v_t}$*-speed of troley* .

On the table 3 and table 4 are given chemical properties of S235JR steel and chemical properties of wire SW-702Si [8] which we have used during welding of plates .

Table 3. Chemical properties of S235JR steel

Steel	C max. %			Mn max. %	Si max. %	P max. %	S max. %	N max. %	Cu max. %	Other max. %	CEV max. %		
	Nominal thickness mm										Nominal thickness mm		
	≤16	>16 ≤40	>40								≤30	>30 ≤40	>40 ≤125
S235JR	0,17	0,17	0,20	1,40	-	0.040	0,040	0,012	0,55	-	0,35	0,35	0,38

Table 4. Chemical properties of wire(wire SW-702Si)

C	Si	Mn
0.08	0.20	1.00

Fig 2. a) plate number 5 and it's welding seam with reference number 5.1, 5.2, 5.3 and 5.4

b) moments during welding of plate 5.

2.2 Measure device HARTIP 3000 Portable Metal Hardness Tester

The HARTIP 3000 device emerges as a groundbreaking solution in the realm of portable metal hardness testing, embodying a fusion of cutting-edge technology and user-friendly design. Crafted to meet the demanding needs of industries where accuracy and mobility are paramount, this device redefines the landscape of metal hardness assessment. Compact and portable, the HARTIP 3000 brings laboratory-grade precision directly to the field, allowing for on-the-spot hardness testing of diverse metallic surfaces [9]. Designed for ease of use, its intuitive interface ensures that both seasoned professionals and novices alike can obtain accurate and reliable hardness measurements effortlessly. Equipped with advanced features, including a high-resolution LCD display and a range of selectable impact devices, the HARTIP 3000 caters to a broad spectrum of applications across industries such as manufacturing, construction, and quality control. This portable metal hardness tester promises not only efficiency in operation but also versatility in accommodating various testing scenarios and material types.

In this era of heightened quality standards and stringent specifications, the HARTIP 3000 stands as a beacon of innovation, offering a robust solution for precise, on-the-go metal hardness assessment. As we delve into the features and capabilities of this cutting-edge device, a new standard for portable hardness testing unfolds, promising to elevate the efficiency and accuracy of hardness measurements across diverse industrial landscapes.

The HARTIP 3000 Portable Metal Hardness Tester which is shown on figure 3.

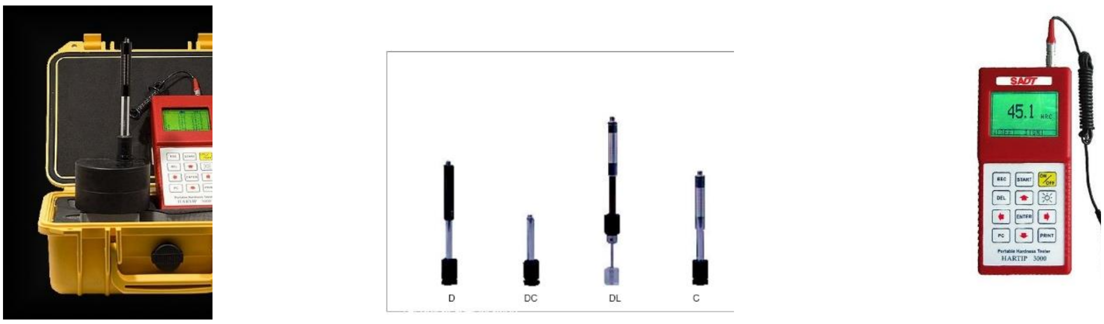


Fig 3. Measurement device HARTIP 3000 Portable Metal Hardness Tester

3 Results and discussion

3.1 Measument of value of hardness welding seam nr. 5.1 of plate 5

Weld parameters (I= 400 A, U= 42V , d_w = 2.4 mm, v_w = 6.0 mm/s , v_t = 6.0 mm/s) earn (overheight h= 0.417mm**,** width b= 12.128mm).

Table 5. Value of hardness data (LDL- Leeb hardness value used with impact device DL, HV- Vicker hardness value, HB- Brinell hardness value, HRB- Rockwell B hardness value, HRC- Rockwell C hardness value, HSD – Shore hardness value)

Nr.	LDL	HV	HB	HRB
1.	593	104	103	58.9
2.	623	130	128	72.8
3.	607	115	114	66.0
4.	624	131	129	73.2
5.	642	148	146	79.6
6.	600	109	109	62.6
7.	630	136	135	75.5
8.	604	113	112	64.5
9.	610	118	117	67.3
$V_{averege}$	615	122	121	69.5
10.	651	157	155	82.4
11.	576	91	91	48.6
12.	598	108	107	61.5
13.	603	112	111	64.0
14.	588	100	99	56.1
15.	623	130	128	72.8
16.	630	136	135	75.5
17.	630	136	135	75.5
18.	612	120	119	68.2
$V_{average}$	612	120	119	68.2
19.	626	133	131	74.0
20.	627	133	132	74.4
21.	629	135	134	75.1

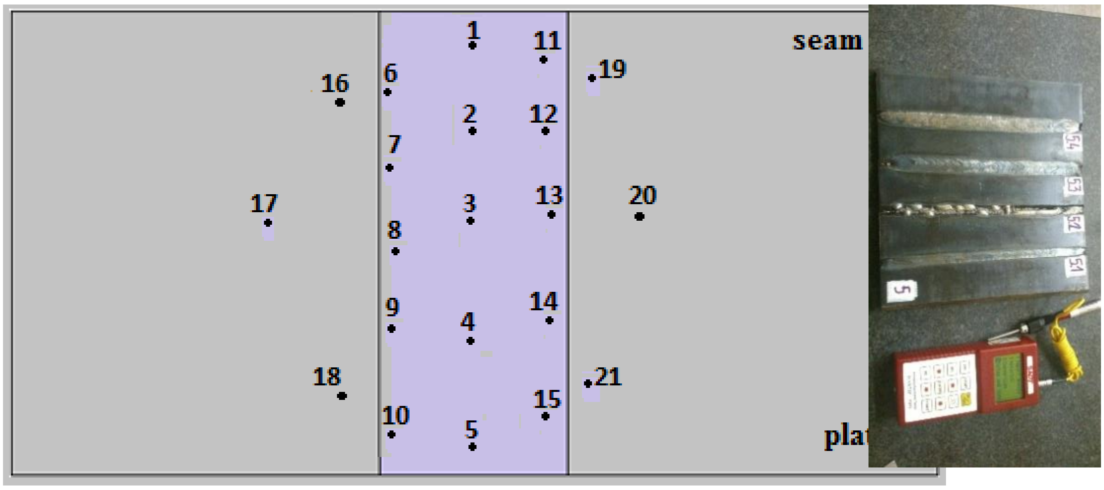


Fig 4. Data point of measurments of the welding seam 5.1 at plate 5.

3.2 Measument of value of hardness welding seam nr. 5.3 of plate 5

Weld parameters (I = 310 A, U = 32 V , d_w = 2.4 mm, v_w = 5.3 mm/s , v_t = 5.0 mm/s) earn (

overheight h=0.55 mm, width b=20.05mm)

Table 6. Value of hardness data (LDL- Leeb hardness value used with impact device DL, HV- Vicker hardness value, HB- Brinell hardness value, HRB- Rockwell B hardness value, HRC- Rockwell C hardness value, HSD – Shore hardness value)

Nr.	LDL	HV	HB	HRB
1.	659	166	163	84.8
2.	648	154	152	81.5
3.	628	134	133	74.7
4.	648	154	152	81.5
5.	674	128	179	88.7
6.	606	114	114	65.5
7.	609	117	116	66.9
8.	631	137	136	75.8
9.	618	125	124	70.8
$V_{average}$	636	142	141	77.6
10.	620	127	126	71.6
11.	610	118	117	67.3
12.	626	133	131	74.0
13.	646	152	150	80.9
14.	615	122	121	69.5
15.	631	137	136	75.8
16.	627	133	132	74.4
17.	632	138	137	76.2
18.	638	144	142	78.3
$V_{average}$	627	133	132	74.4
19.	623	130	128	72.8
20.	635	141	140	77.3
21.	641	147	145	79.3

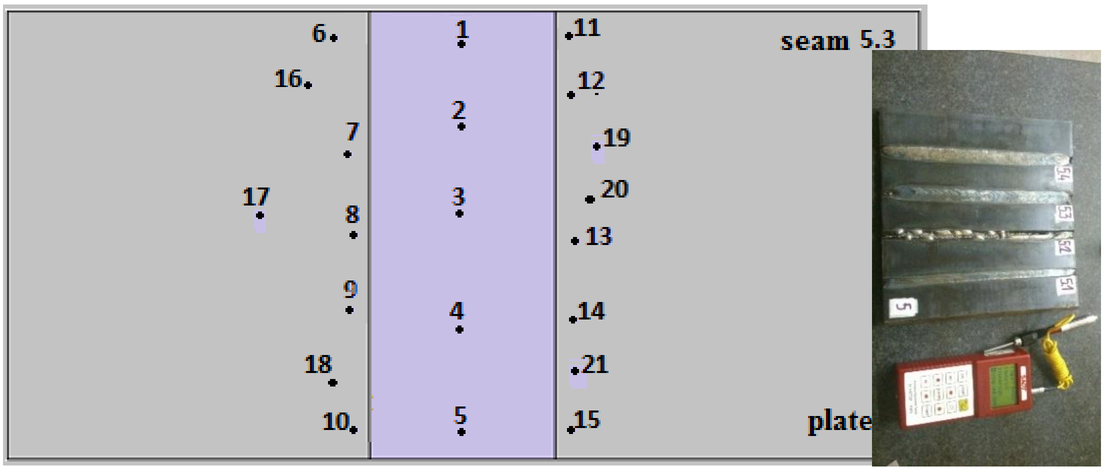


Fig 5. Data point of measurments of the welding seam 5.3 at plate 5.

3.3 Measument of value of hardness welding seam nr. 5.4 of plate 5

Weld parameters (I = 350 A, U = 37 V , d_w = 2.4 mm, v_w = 5.5 mm/s , v_t = 6.0 mm/s) earn (overheight h=0.822mm, width b=21.132mm)

Table 7. Value of hardness data (LDL- Leeb hardness value used with impact device DL, HV- Vicker hardness value, HB- Brinell hardness value, HRB- Rockwell B hardness value, HRC- Rockwell C hardness value, HSD – Shore hardness value)

Nr.	LDL	HV	HB	HRB
1.	634	140	139	76.9
2.	627	133	132	74.4
3.	603	112	111	64.0
4.	607	115	114	66.0
5.	656	162	160	83.9
6.	617	124	123	70.4
7.	589	110	100	56.7
8.	621	128	127	72.0
9.	579	93	93	50.6
$V_{average}$	615	121	121	69.5
10.	610	118	117	67.3
11.	604	113	112	64.5
12.	609	117	116	66.9
13.	614	121	120	69.1
14.	619	126	125	71.2
15.	610	118	117	67.3
16.	605	114	113	65.0
17.	607	115	114	66.0
18.	613	121	120	68.7
$V_{average}$	610	118	117	67.3
19.	610	118	117	67.3
20.	605	114	113	65.0
21.	618	125	124	70.8

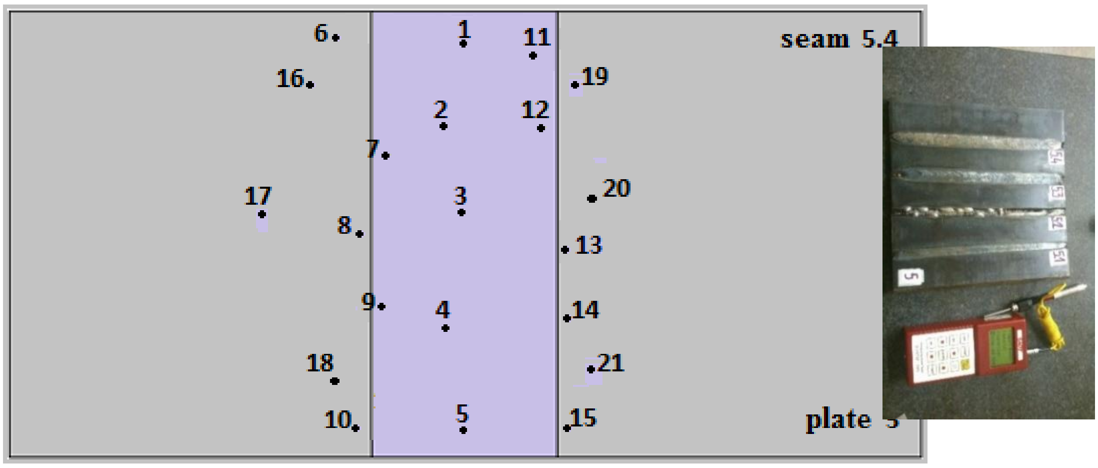


Fig 6. Data point of measurments of the welding seam 5.4 at plate 5.

3.4 Measument of value of hardness welding seam nr. 5.2 of plate 5

Weld parameters ($I = 270A$, $U = 28V$, $d_w = 2.4$ mm, $v_w = 4.0$ mm/s , $v_t = 4.5$ mm/s)

Table 8. Value of hardness data (LDL- Leeb hardness value used with impact device DL, HV- Vicker hardness value, HB- Brinell hardness value, HRB- Rockwell B hardness value, HRC-

Rockwell C hardness value, HSD – Shore hardness value)

Nr.	LDL	HV	HB	HRB	HRC	HSD
1.	674	182	179	88.7	-	-
2.	638	144	142	78.3	-	-
3.	704	217	213	95.6	-	31.4
4.	628	134	133	74.7	-	-
5.	728	248	243	-	22.5	35.9
6.	681	190	187	90.5	-	-
7.	604	113	112	64.5	-	-
8.	648	154	152	81.5	-	-
9.	622	129	128	72.4	-	-
$V_{average}$	659	166	163	84.8	-	-
10.	616	123	122	70.0	-	-
11.	633	139	138	76.6	-	-
12.	630	136	135	75.5	-	-

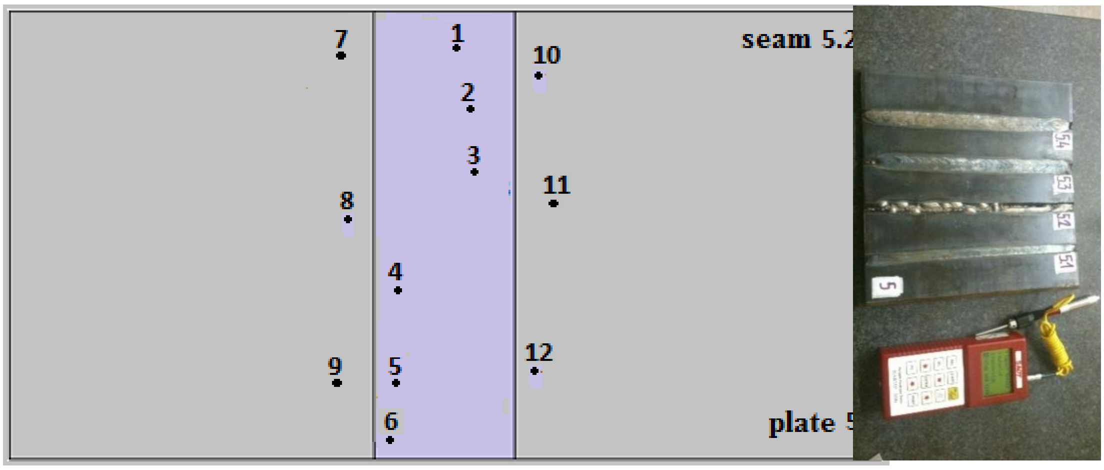
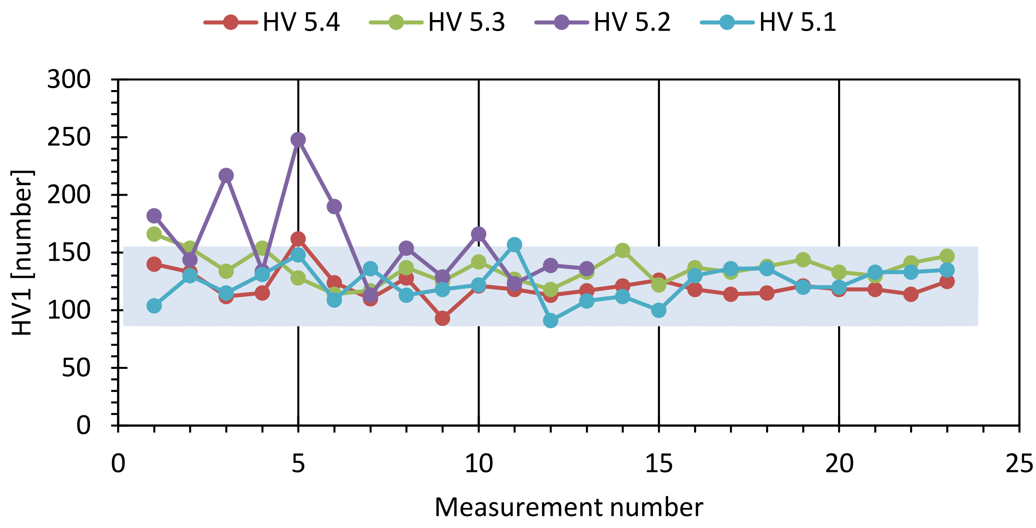


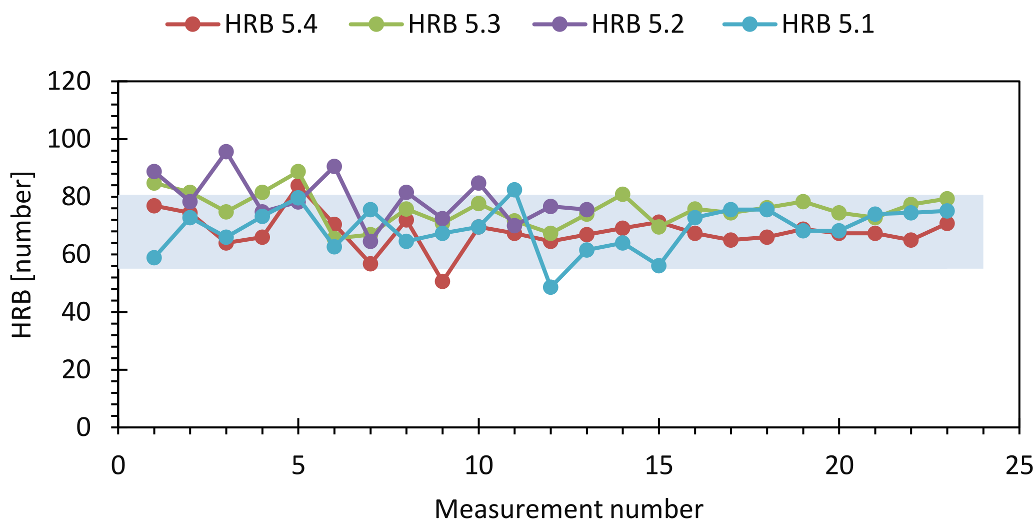
Fig 7. Data point of measurments of the welding seam 5.2 at plate 5

The data of the hardness collected by using divice HARTIP 3000 Portable Metal Hardness Tester (divice which is disigned to measure hardness of metals) were done in accordance with standard EN 1043-1:1996 for hardness testing of metallic materials [10] and to disign the graphs and diagrams Excel was used.

Comparison of hardness value according to Vickers (HV), Brinell (HB) and Rockwell B (HRB) were presented on the next subchapter were for three different hardness number were prepared separated diagrams in order to have better visualization and clear comparison.

3.5 Comperison of hardness value of the welding seam 5.1, 5.2, 5.3 and 5.4 at plate 5





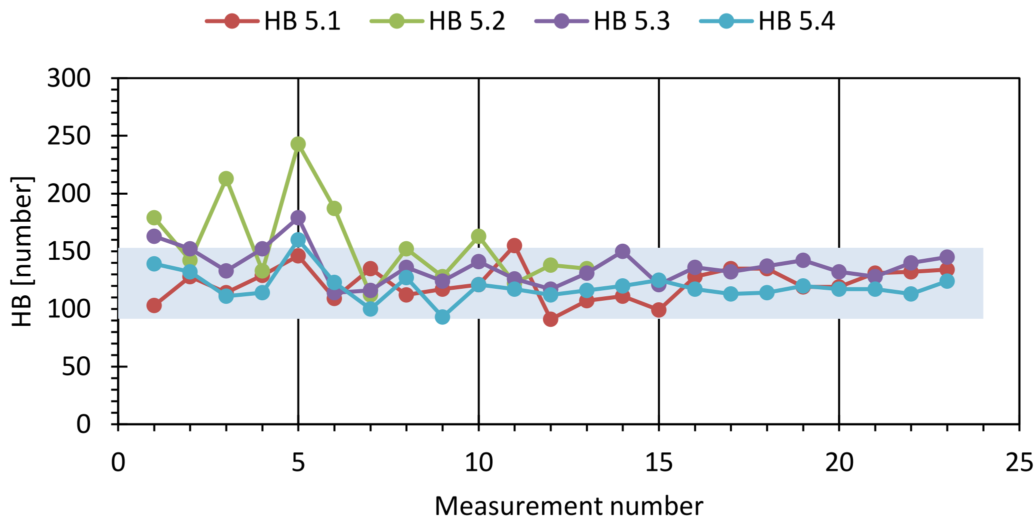


Fig 8. Comparison of hardness value according to Vickers (HV), Brinell (HB) and Rockwell B (HRB) of the welding seam 5.1, 5.2, 5.3 and 5.4 at plate 5

4 Conclusion

Based on the value of the hardness the following conclusion could be drawn from the above investigation :

- optimal welding parameters applied on the S235JR steel are on the 5.4 seam welding with these values (intensity I=350 A, tension U=37 V, speed of the wire v_w =5.5 mm/s, diameter of the wire d_w =2.4 mm, speed of the troley v_t=6.0 mm/s),
- parameters of the welding applied at welding bead 5.4 give uniform distribution of the value of hardness between the point of measurements.
- Welding bead is characterized also by a smooth surface and stable arc.
- Welding beads 5.1, 5.2 and 5.3 are characterized with a great difference in some of point of measurements, surface of the welding bead is not smooth and is characterized by hills and valleys, and sometimes the arc is unstable.

Therefore we suggest to all manufactures which use the S235JR steel to apply the same parameters of welding which we applied at welding seam 5.4 in order to achieve an uniform hardness.

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3D Printing of the Bike Frame Prototype

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Abstract. Design is the phase where abstract ideas tend to end up with form and function. There have been a lot of improvements in the last decade in design for 3D Printing. From an advanced manufacturing point of view, 3D Printing is a promising technology to come up with prototypes and products whose geometry is relatively complex, and in some cases when the parts are integrated from several pieces to one. This case can be recognized in the bike frame, which is our case study as an example. The problem that needs to be questioned is: Can we 3D Print the bike frame as a whole? The strengths and weaknesses of actual development will be presented in this article.

Keywords: 3D Printing, Bike Frame, Design, Complex, Integration.

3 Introduction

Recently, advanced production technologies have become very applicable. Based on the steps for product development, the prototype must be generated as soon as possible so that we have data from the physical model. Based on this, 3D Printing is a good opportunity to turn the digital CAD model into a physical model. Related to CAD model in advance we can do other analyses for optimization that make the whole process more flexible. In this research work, the possibility to produce the prototype through 3D Printing is presented. The analyses are important to have more clarifications about the procedure and preliminary calculations for optimization in cases where material is different from the original model.

The paper is organized in this way. In Section 2, the 3D Printing and process description are presented. In Section 3, data from the design of the bike frame was collected and finite element analysis (FEA) as well as optimization was calculated. In Section 4, the conclusions will derive the actual situation and limitations.

4 3D Printing

There are many terms used by the engineering communities around the world to describe this technology. Perhaps this is due to the versatility and continuous development of the technology. In the public domain, the most commonly used term is 3D Printing. Previously, the most commonly used term was Rapid Prototyping [1].

A recently formed technical committee within ASTM international agreed that new terminology should be adopted. While this is still under debate, recently adopted ASTM consensus standards now use the term Additive Manufacturing. Referred to in short as AM, the basic principle of this technology is that a model, initially generated using a 3D CAD system, can be fabricated directly without the need for process planning [2].

Additive processes, which generate parts in a layered manner, first appeared with stereolithographiy (SLA). Since then, several new ideas have been put forth, many patents have been approved, new processes have been invented, and a few have eventually been commercialized. The development of AM can be described in four primary areas. The AM wheel in Figure 1 depicts these four key aspects of AM. They are: input, method, material and applications [1].

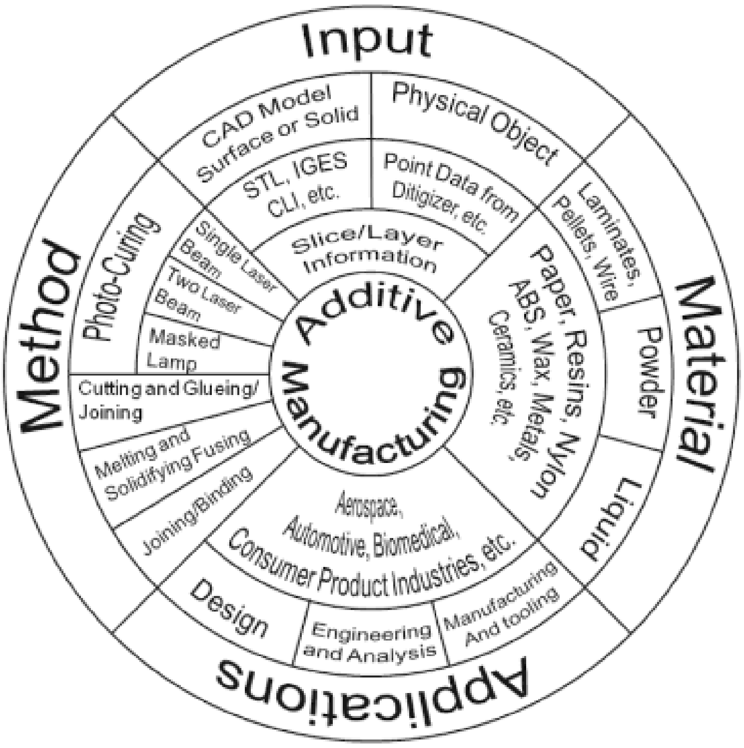


Fig. 1. The AM wheel with four major aspects [1].

All AM systems generally have a similar sort of process chain. Such a generalized process chain is shown in Figure 2. There are a total of five steps in the chain and these are: Step 1: 3D modeling, Step 2: data conversion and transmission, Step 3: checking and preparing, Step 4: building and Step 5: post processing [1].

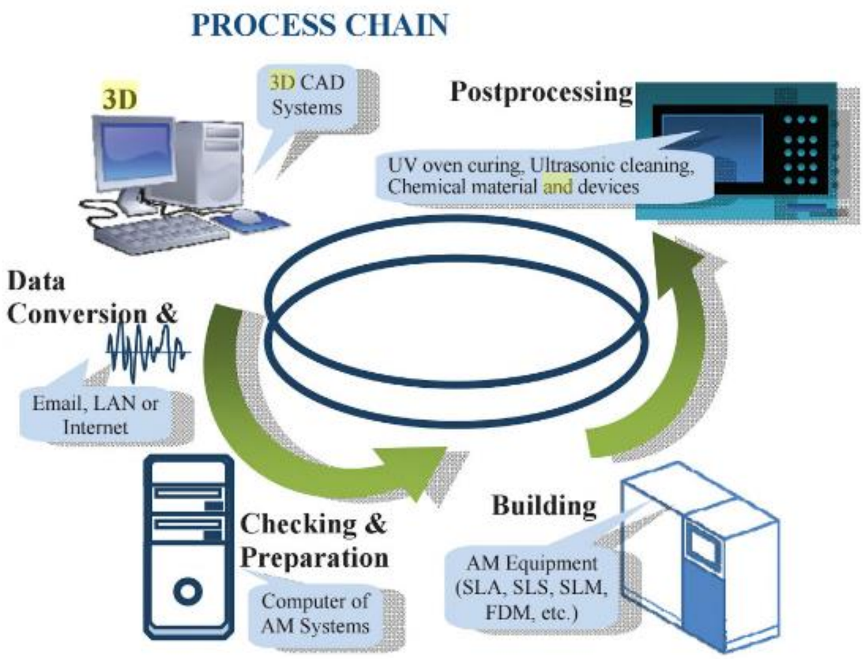
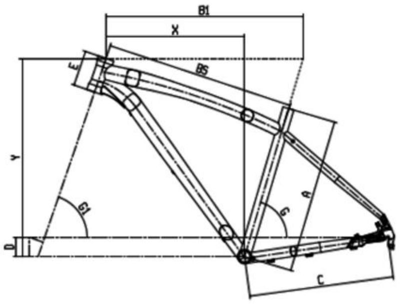


Fig. 2. Process chain of AM systems [1].

5 Bike Frame Analysis

The most popular frame design is known as the diamond or double- triangle [3]. The brands of the Bianchi group have met those of Cycleurope to constitute a unique network in the two-wheel market. Today Cycleurope can implement the most advanced operative synergies involving prestigious European companies, amongst which Bianchi represents the flagship brand. The strategic investments of the group aim at two outstanding targets: the development of a highly-advanced product and the establishment of Bianchi brand on international markets [4].

CAD involves the use of computers to create product design drawing and 3D models [9]. Today CAD systems are covering most of the activities in the design cycle, they are recording all product data, and they are used as a platform for collaboration between remotely placed design teams. CAD systems can shorten the design time of a product [5]. Therefore, the product can be introduced earlier in the market, providing many advantages to the company. CAD systems enable the application of concurrent engineering and can have significant influence on final product cost, functionality, and quality. The model in Figure 3 is Bianchi frame, so it's the first model from the table (M17"), according to all the parameters presented.

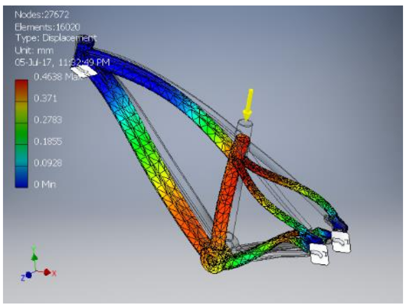


SIZE	A	B1	BS	C	D	E	G	G1	Y	X
M 17"	430	590	576	450	60	100	73.5°	71°	606	411
L 19"	480	610	587	450	60	110	73.5°	71°	615	428
XL 21"	530	630	606	450	60	120	73.5°	71°	625	445

Fig. 3. Bianchi frame M17" [6].

3D CAD is done with Autodesk Inventor, where two models are created: ABS plastics model and aluminum piping model.

FEA on bicycle frames has become a common activity for bicycle designers and engineers in the hope of improving the performance of frames. This is typically achieved by balancing priorities for key requirements, including minimizing the mass of the frame, maximizing lateral stiffness in the load transfer from the hands and feet to the drive, maximizing the strength capabilities of the frame to allow for a higher load capacity or better load distribution, and adjusting the vertical compliance of the frame to tune the softness of the ride [7]. The core of the FEA method is an idealization of the object or continuum by a finite number of discrete variables. The Finite-Element program assembles the stiffness matrices for simple elements to form the global stiffness matrix for the entire model [5]. This stiffness matrix is solved for the unknown displacements, given the known forces and boundary conditions. From the displacement at the nodes, the stresses in each element can then be calculated. A comparison of the two models has been made where one is realized according to the real parameters of the aluminum material while the other model is realized by ABS plastic as a possibility to produce in 3D Printer. From the analyzes carried out in the software it emerges that for a similar load in both models with F = 800 [N] we have different deviations based on the mechanical properties of the models as we show in Figure 4.



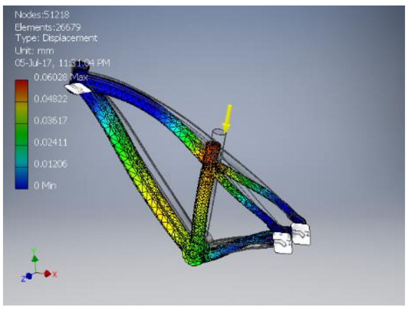


Fig. 4. FEA of bike frame: ABS plastic (left), aluminum (right).

There is the possibility of optimizing the approximation of values in the case of the ABS plastic model but the ability of the material is the one that requires great structural changes. The general work flow of optimization process can be shown in Figure 5.

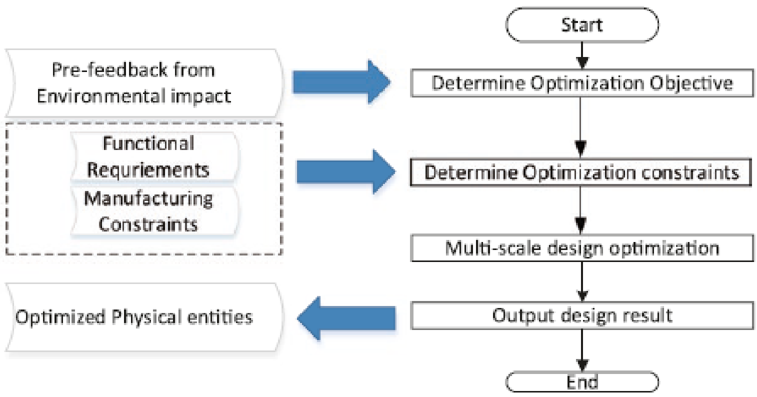


Fig. 5. General workflow of optimization process [10].

Finally, in Figure 6 we can see the CAD model of bike frame in virtual 3D Printer machine. As we know we can choose different 3D Printing patterns with wide range of scope [8], especially for complex designs like bike frame.

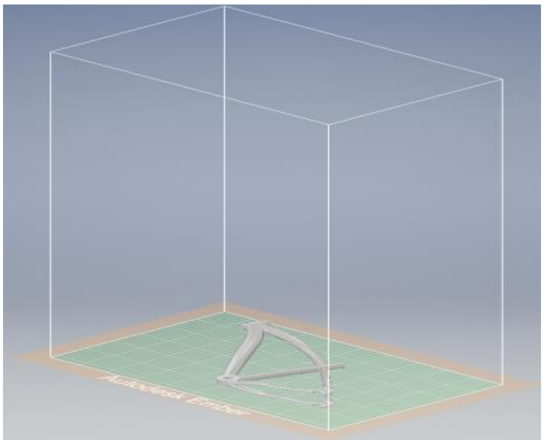


Fig. 6. Virtual 3D Printing of bike frame.

6 Conclusions

Prototypes are very important for the realization of concepts in design, manufacturing, and performing other analyses. Prototyping is an essential step of product development and manufacturing cycles required for assessing the form, fit, and functionality of a design before a significant investment is made. In the product design and development process, designers can have difficulties discussing many design details on the computer screen, especially for complex shapes. At this moment, the physical model plays an important role from which we can find whether the final design is the same as the original design concept or not. Prototyping using 3D Printing methods is an advanced tool for new product development. Moreover, the comparison of the two models through the FEA of the bike frame shows the difference in stress analysis.

The model (bike frame) can be scaled to fit the corresponding capacity of the 3D Printing machine regarding different AM technologies. This presents the actual limitations of AM technologies when the part geometry is relatively big.

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Katalogimi në botim – (CIP)
Biblioteka Kombëtare e Kosovës “Pjetër Bogdani”

62(062)
061.3(496.51)

Proceedings International Conference : proceedings of the 12th UBT Annual International Conference : international Conference on Mechatronics, System Engineering and Robotics / edited by Edmond Hajrizi. - Prishtinë : UBT, 2024. - 49 f. : ilustr. ; 30 cm.

1. Hajrizi, Edmond

ISBN 978-9951-982-09-2

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ISBN 978-9951-982-09-2