PROJ Collective Project –

Remotely controlled bending bench

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1.Introduction

This comprehensive report documents the collaborative research project undertaken by the 8th semester students of the MSc Advanced Mechatronics program at USMB, Polytech Annecy-Chambery, as part of the Collective Project course. The project, entitled "Creation of a Remotely Controlled Bending Bench," delves into the intriguing realm of remotely controlling the physical world, a formidable challenge that researchers are tackling by leveraging various technologies to provide students with real-time access to remote laboratories in the domains of physics and engineering. These remote laboratories offer unparalleled flexibility, enabling students to engage with expensive and sophisticated equipment from any location and at any time.

Building upon a previously accomplished testing bending bench project, our study endeavors to expand the horizons of connectivity to the server and enhance the overall functionality by introducing a camera that enables real-time visualization of the experimental processes. By incorporating this innovative feature, we seek to further empower students' ability to observe and comprehend experiments unfolding in real-life, promoting a richer learning experience.

Within this report, we embark on a comprehensive journey, commencing with a concise overview of remote laboratories and a precise definition of remote experiments. Subsequently, we delve into the intricate design aspects of a remote bending experiment, encompassing both mechanical and electronic components. Moreover, we showcase the process of collecting measurement data from a web server deployed on a Raspberry Pi through an Android application—an intuitive interface that empowers users to grasp and apply theoretical concepts in a tangible, real-life context.

As we conclude this report, we reflect upon the individual outcomes of this collective research endeavor and present plans for future developments. The overarching objective of our project is to introduce E-Labs into the realm of education. To achieve this, our experiments revolve around remote bending tests, allowing us to remotely assess the mechanical parameters of beams while enabling data analysis through an intuitive interface. By applying our scientific and technological acumen, we aim to create robust mechatronics systems that not only push the boundaries of innovation but also enhance collaborative work within our group.

Through meticulous exploration and analysis, this report strives to encapsulate the essence of our research project while providing valuable insights for the advancement of remote laboratories in education.

2.Mechanical Aspects

2.1Experimental Evaluation of Material Strength and Ductility

In the realm of material analysis, there exists a prominent testing method known as bend testing, which is also referred to as flexure testing or transverse beam testing. This form of destructive testing serves as a means to ascertain the strength and ductility of various materials. The essence of the test lies in subjecting a specimen to bending forces until it reaches the point of fracture. By conducting bend tests, it becomes possible to evaluate material behavior under diverse conditions encompassing tension, compression, or simple beam loading. This method finds widespread application across a range of materials, including metals, plastics, and composites. Although the prevalent approach is the three-point bend test, which measures the flexural strength of materials, our study specifically focuses on a distinctive variant known as end-loaded cantilever beams.

2.2 Insights into Cantilever Beams

Cantilever beams, renowned for their unique structural properties, derive support solely from a single point, typically furnished with a fixed support mechanism. In order to establish a state of static equilibrium, it is imperative for the support to be immobilized, capable of withstanding forces and moments emanating from all directions. The remaining length of the beam extends freely, without any additional support on the opposing end. These exceptional beams are inherently constrained by a sole point of support, as exemplified in the aforementioned scenario. The absence of support on one end necessitates greater deflection of such members, given their unidirectional support configuration.

For the calculation of cantilever beam deflection, a straightforward equation can be employed: Deflection = $(WL^3)/(3E*I)$, wherein W denotes the force applied at the endpoint, L signifies the length of the cantilever beam, E represents Young's Modulus, and I corresponds to the Moment of Inertia.

2.3 Analyzing Beam Deflection

Within the domain of structural engineering, deflection signifies the displacement or movement experienced by a beam or node from its original position. This phenomenon arises due to the application of external forces and loads upon the structural member. It is also known by the term "displacement" and may arise from externally applied loads or even the weight of the structure itself, encompassing the influence of gravitational force.

Cantilever beams, with their distinctive support configuration where one end remains unattached, find widespread utilization in a multitude of structures, such as bridges, balconies, and walls. These beams epitomize the essence of strength and stability, capitalizing on the concept of unidirectional support to fulfill structural requirements.

The assessment of a beam's flexural strength can be effectively accomplished through the utilization of the cantilever beam test. This testing method involves the secure fixation of a beam at one end while leaving the other end free. Subsequently, a progressively increasing load is applied to the unrestricted end until the point of failure is reached. Widely employed in the field of engineering, cantilever beam tests offer valuable insights into material behavior and structural performance.

By determining the load at which failure occurs during the cantilever beam test, it becomes feasible to calculate the stress experienced at the top portion of the beam. This stress analysis aids in the comprehensive understanding of the beam's strength characteristics and enables engineers to make informed decisions pertaining to structural design and material selection.

3. Comprehensive Examination of Existing Literature

3.1 Overview of Bending Tests

In order to determine the tensile strength of brittle materials that pose difficulties in uniaxial stress testing due to grip cracking, bending tests serve as a reliable alternative. The figure illustrates the most commonly employed bending test variants, including cantilever, 3-point bending, 4-point bending, and G-torsion tests.

During the bending test, meticulous recording of bending force and deflection data takes place. These data points subsequently facilitate the determination of material properties through rigorous analysis. A stress-strain curve encapsulates the entire testing process and can be complemented by video documentation. Bending tests specifically focus on investigating a material's bending behavior under a singular axis of bending force, particularly accentuating the assessment of bending strength in the case of brittle materials. However, when dealing with ductile materials, additional insights such as the limit yield point, the highest practically achievable bending angle, and Young's modulus can be ascertained, primarily in scenarios involving elastic deformation.

3.2Exploring the Realm of Remote-Controlled Experiments

Remote labs offer a plethora of opportunities for students to engage in experimental activities and derive tangible learning outcomes. These remote labs extend beyond mere demonstration setups, as they provide a platform for conducting actual remote-controlled experiments. While the advantages of remote labs are manifold, the construction process also poses its fair share of challenges. Clear benefits for students emerge, such as round-the-clock accessibility, effectively fostering motivation for continued learning. Nonetheless, the development of user-friendly remote lab interfaces, ensuring seamless remote experiences, and implementing robust assessment and feedback mechanisms remain significant challenges that necessitate careful consideration.

Design and components

Servomotor to change the position

Strain gauge

A strain gauge is a sensor that detects changes in electrical resistance due to strain. Strain is the deformation of material caused by applied stress, which is the force divided by the material's cross-sectional area.

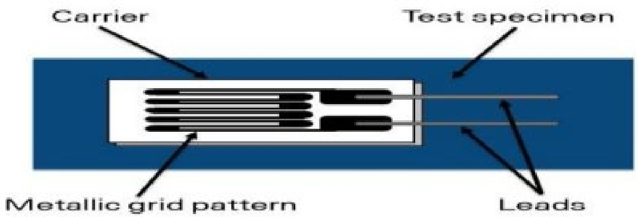


Figure 17 :Strain gauge

Force sensor

A force sensor is a transducer that converts physical input force, such as weight, compression, torque, strain, stress, or pressure, into an electrical output signal. This signal represents the magnitude of the force.

Raspberry pi

The Raspberry Pi is a compact computer with an ARM processor, similar to the Arduino, a freely licensed circuit board.

4. study of remotely controlled systems

4.1 General composition of a remotely controlled system

After reading different research papers about remotely controlled systems, we were able to narrow down what were the main parts needed for a remotely controlled system to work properly.

These systems were often made of the following parts:

1- **Remote Control Device:** This is the device used by the operator to control the system. It could be a dedicated controller, a computer, or even a smartphone. The interface could be physical buttons, a touchscreen interface, or even voice commands.

2- **Communication Link:** This is the medium through which signals are sent from the remote control device to the system being controlled. It could be a wired connection, such as Ethernet, or a wireless connection, such as Wi-Fi, Bluetooth, or a cellular data connection.

3- **Controlled System:** This is the system being controlled. It could be a simple device like a drone or a robot, or a complex system like an industrial process control system.

4- **Sensors:** These are used to monitor the state of the controlled system and its environment. For example, a drone might have sensors to monitor its altitude, orientation, speed, and battery level.

5- **Actuators:** These are the components that perform actions in the controlled system based on the commands received from the remote control device. For example, in a drone, the actuators would be the motors that move the drone.

6- **Control Unit:** This is the 'brain' of the controlled system. It receives signals from the remote control device via the communication link, processes these signals, and controls the actuators accordingly. It also monitors the sensors and can send information back to the remote control device.

This structure allows the operator to control the system remotely, with the communication link allowing two-way communication between the operator and the system. Of course, the specifics of how all these components are designed and put together would depend on the specific requirements of the system. There are many different technologies and techniques available, each with their own strengths and weaknesses.

4.2 Our remotely controlled Testing bench Structure

In our case the remote control device is a raspberry pi. This raspberry pi is connected to the testing bench and collects data from the different sensors, and then using another python code and program that's already put into the raspberry pi, we can view this data on the computer but initially we need to connect the raspberry pi to the computer.

The communication link when we were given the project was an ethernet cable, it was using this cable that we were able to get the data from the raspberry pi to the computer.

The controlled system is a beam and a servo motor which are controlled once we run the python program; the program has the automatic option, once you click on it the servo motor starts turning, letting the metal beam upwards and downwards so that we can measure the bending force.

5. Solutions for a remotely controlled testing bench

5.1 Aims

After having met our project owner we came up with 4 aims to ensure a proper remotely working system;

The first being that the computer should not be connected to the raspberry pi anymore. The testing bench/raspberry pi should be able to send data remotely to the computer.

The second, that the testing bench should be able to send data to the Jeedom API online so that we have a way to collect the data onto an online dashboard.

Lastly, this data that is sent to the computer should be remotely accessible onto the "fete de la science" website, so that anyone can have access to the data online.

5.2 Server connection

When we were given the bending bench a ethernet cable was required in order to gain data from the bending bench to the computer. In order to make it work remotely, we started doing some research and found out that we actually need to have a network server to connect both devices. For this, since we were still planning on using the bending bench in the mechatronic house, we decided to use the local server of the mechatronic house, using both device's mac addresses. A MAC (Media Access Control) address is a unique identifier assigned to a network interface controller (NIC) for use as a network address in communications within a network segment. It's a hardware ID that uniquely identifies each device that can connect to a network. In local area networks (LAN), these are often Ethernet addresses.

Here's the general process on how we use MAC addresses to control access to a local network, using a feature on many routers known as MAC address filtering:

1. On most devices, you can find the MAC address in the device's network settings or system information. The process differs from device to device. For example, on a Windows PC, you can use the "ipconfig /all" command in the Command Prompt, and on a Mac, you can use the "Network" option in "System Preferences".

2. Access Your Router's Admin Interface: You usually do this by typing the router's IP address into a web browser on a device connected to your network. The exact IP address and login details vary, but common ones are 192.168.1.1 or 192.168.0.1. The username and password might be on a sticker on the router itself, in the router's manual, or online.

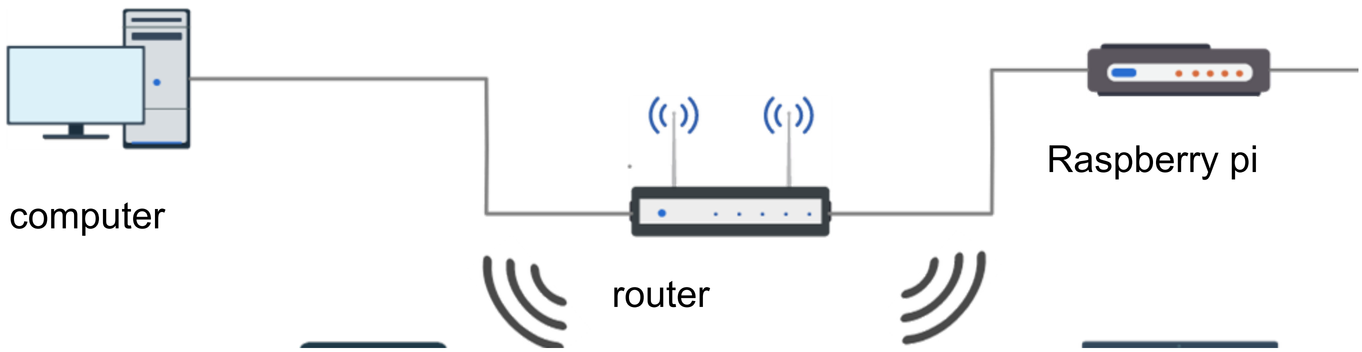
3. Find the MAC Filtering Section: This is usually in the security settings, though it varies between different routers. It might be listed under "Wireless" or "Wireless Settings". It may be labeled as "MAC Address Filtering", "MAC Address Control", "Access Control", or something similar.

4. Add the MAC Address: Once you find the right place, you can usually add a new MAC address, select whether to allow or deny it, and then save or apply the settings. You want to choose to "allow" your device's MAC address.

This way, only devices with MAC addresses on the approved list can connect to your network. It's one method to add an extra layer of security to your network. However, it should not be your only security measure, as MAC addresses can be spoofed or imitated.

After we connected the MAC addresses to the local server we were given the IP addresses that we need to use for the computer and the raspberry pi, and with these IPs addresses we were able to connect both devices without using a wire.

New Configuration



5.3 Creating an online website with ip address

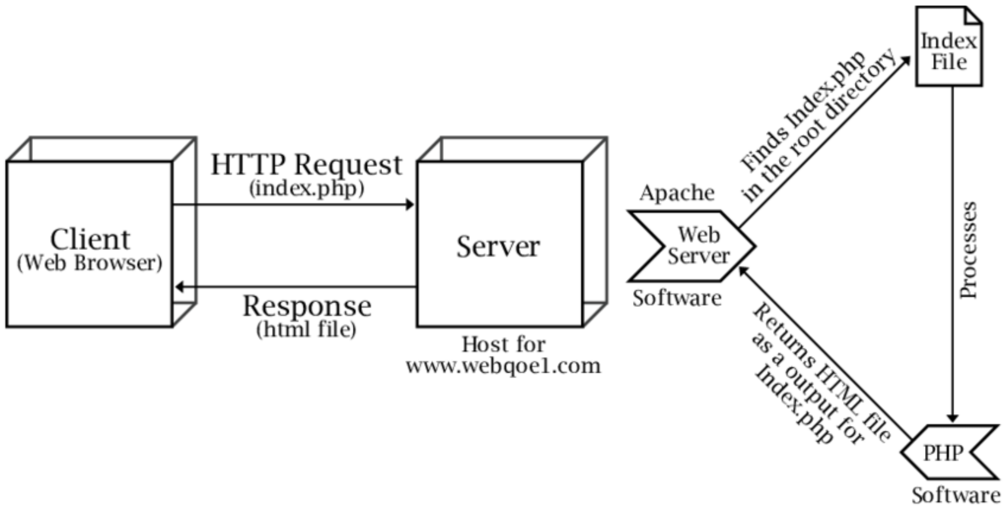
Firstly, we needed to install Apache, PHP, and optionally MySQL (together known as a LAMP stack) on our Raspberry Pi, which runs on a Linux operating system. Apache is a web server software that serves our website's files and content to users, PHP is a scripting language used for creating dynamic web pages, and MySQL is a database management system used for storing and retrieving our website's data.

Once installed, we set up our website's files in Apache's web root directory. These files are what users see when they access our site. They can be simple HTML, CSS, and JavaScript files, or PHP scripts for dynamic content.

We needed to configure our Apache settings (like enabling .htaccess files for URL rewriting), and if we're using MySQL, we'll need to set up our databases and tables.

To make our Raspberry Pi website accessible from the internet, we'll need to configure our home router to forward incoming requests on port 80 (HTTP) or 443 (HTTPS) to our Raspberry Pi's local IP address.

On the HTML code that created the website, we wrote the python program by using commands that transfer it into an html code so that the python code that controlled the bending bench was put into the website.



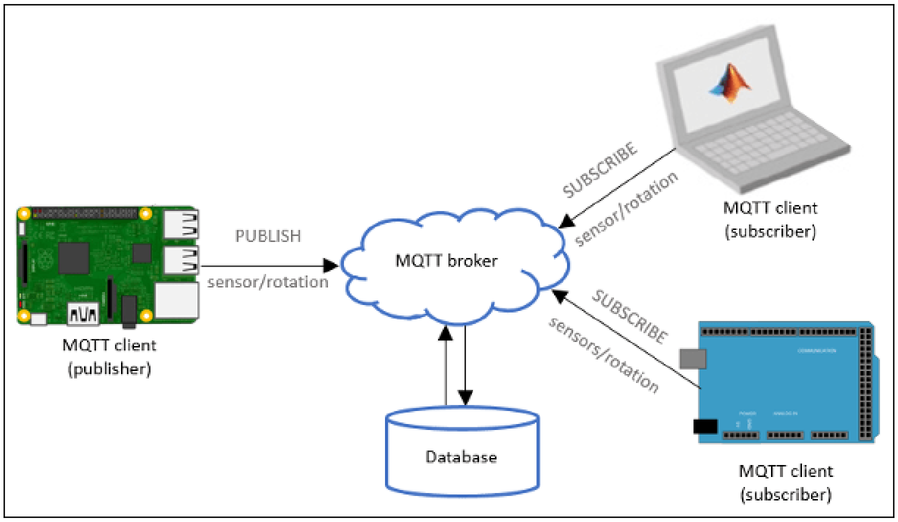
5.4 sending data from the raspberry to Jeedom API

Connecting a Raspberry Pi to the Jeedom API and sending data to a computer involves a few steps. First, we would need to ensure that our Raspberry Pi has a stable connection to the Internet and has the necessary software installed for making HTTP requests, such as Python with the 'requests' library.

Once we've configured the Raspberry Pi, we would connect to the Jeedom API. The Jeedom API provides an interface for interacting with Jeedom, a home automation platform. To send data to the Jeedom API, we would craft an HTTP request containing the data we want to send. This request is then sent to the Jeedom server using its API.

After the Jeedom server receives the request, it can process the data as needed. The data might trigger some action within Jeedom or be stored for later use. For instance, if we're using a sensor to monitor temperature on the Raspberry Pi, we can send this data to Jeedom to track temperature changes over time.

To send the data from the Jeedom server to a computer, we would need to make an HTTP request from the computer to the Jeedom server. We could set up a script on the computer that periodically checks the Jeedom server for new data and downloads it.



Conclusion

This project demonstrated successful utilization of modern computational and networking technologies to establish remote control capabilities for a bending bench. By integrating a Raspberry Pi microcomputer with the bench, we were able to leverage the Raspberry Pi's network interfacing and computing abilities to act as a bridge between the bench's control system and a network.

Connecting the Raspberry Pi and our computer to a local server facilitated real-time data exchange, transforming the standalone bench into a networked device that could be controlled remotely. We leveraged Apache, a popular open-source web server software, to create a user interface on the server. The data of the bending bench, captured by the Raspberry Pi, was transmitted successfully to this webpage. This allowed us not only to view the status of the bending bench in real time but also potentially to send commands to the bending bench from the interface.

This achievement showcases the potential of IoT (Internet of Things) in industrial and manufacturing settings, where making traditional machines network-accessible and controllable can lead to more efficient and flexible operations. It also underscores the versatility and power of the Raspberry Pi as an IoT device due to its robust computing capabilities, network interface, and compatibility with open-source software like Apache.

However, it's worth noting that as this system is developed further, considerations must be given to network security, reliability, and potential latency in the control system. Future work might also explore additional features such as creating a more detailed user interface, incorporating more sophisticated control mechanisms, or expanding to control multiple devices.

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