THE TECHNOCRACY
STUDENTS' TECHNICAL COMMITTEE, NIT RAIPUR

AAVARTAN 24-25

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DEPARTMENT OF MECHANICAL ENGINEERING

PROBLEM STATEMENTS

MECH01: UAV surveillance drone

A UAV surveillance drone is an unmanned aerial vehicle equipped with cameras and sensors to gather information from the air for surveillance purposes. It can be used for monitoring and mapping traffic, wildlife, crops, disaster areas, and more. These drones are used to gather information in areas that are difficult or dangerous to access by ground, such as disaster zones, dense forests, or high-security areas. They can help in identifying threats, monitoring wildlife, assessing crop health, and providing situational awareness in various scenarios.

Past Methodology:

Previous approaches might have involved manually piloted drones or fixed surveillance systems, which could be less efficient and flexible compared to autonomous UAVs.

Available solution:

Current solutions include UAVs equipped with high-resolution cameras, thermal imaging, LiDAR, and other sensors. These drones can be autonomous or remotely piloted and can transmit real-time data to a ground station.

Current issues and limitations:

- Battery life: Most UAVs have limited flight times due to battery constraints, which restricts their operational range and endurance.
- Payload capacity: The payload capacity of UAVs is often limited, which can restrict the types and number of sensors that can be carried.
- Regulatory restrictions: There are strict regulations governing the use of UAVs in many countries, which can limit their deployment and operation.
- Autonomy and safety: While UAVs can be autonomous, ensuring their safe operation in dynamic environments with obstacles and other aircraft is a significant challenge.
- Cost: The cost of acquiring, operating, and maintaining UAVs can be prohibitive for some applications.

Applications:

- Infrastructure inspection: UAVs can be used to inspect bridges, pipelines, and other infrastructure for damage or maintenance needs.
- Environmental monitoring: UAVs can monitor wildlife, forests, and water bodies to track changes, detect illegal activities, and support conservation efforts.
- Disaster management: UAVs can provide real-time aerial imagery to aid in disaster response, damage assessment, and search and rescue missions.

Future scopes:

- Improved battery technology: Advances in battery technology could significantly increase flight times and operational range.
- Sensor integration: Future UAVs may carry a wider range of sensors, including hyperspectral imaging, radar, and gas sensors, for more comprehensive data collection.
- Swarm intelligence: UAV swarms could work together to cover larger areas more efficiently and provide redundancy in case of individual UAV failures.
- Regulatory framework: Continued development of regulations and standards could facilitate the safe and widespread use of UAVs in various applications.

Expectations from the team:

Design and fabricate a UAV surveillance drone that collects information for various purposes, ensuring it meets regulatory requirements for monitoring and mapping different areas. The system should be capable of autonomous flight, real-time video streaming, and long-duration operation while maintaining a compact and lightweight design. The drone should also have obstacle-avoidance capabilities and can operate in various environmental conditions.

MECH02: Design and fabrication of a 3-D printing machine

A 3D printing machine, also known as a 3D printer, is a type of additive manufacturing technology that creates three-dimensional objects layer by layer from a digital model. 3D printing machines vary in size, cost, and complexity, with desktop models suitable for hobbyists and professionals, as well as industrial-scale machines used in manufacturing and prototyping.

Past Methodology:

In the past, 3D printing technology was primarily used for rapid prototyping in industries such as automotive, aerospace, and medical. The focus was on quickly creating physical models of parts and products for testing and validation before mass production. Early 3D printers were expensive and primarily used by large companies due to their high cost and complexity. These printers often used proprietary software and materials, limiting accessibility to a broader range of users.

Available solution:

There are several 3D printing solutions available on the market, ranging from desktop printers for hobbyists to industrial-scale machines for manufacturing. Desktop printers are popular for their affordability and ease of use, while resin printers offer higher detail but require more careful handling of liquid resin. Industrial 3D printers are capable of printing with a wide range of materials, including metals and composites, making them ideal for high-performance applications.

Current issues and limitations:

- Speed- 3D printing can be a slow process, especially for complex or large objects.
- Improvements in printing speed are continuously being made, but it remains a limiting factor for mass-production applications.
- Cost- While the cost of 3D printers has decreased over the years, they can still be expensive, especially for high-end industrial models. Additionally, the cost of materials can add up, especially for speciality or high-performance materials.
- Quality and resolution- Achieving high levels of detail and surface finish can be challenging, especially with desktop FDM printers. Resin printers can produce higher-quality prints but are limited in terms of build size and material options.
- Design limitations- Certain designs may be difficult or impossible to 3D print due to overhangs, unsupported features, or other factors. Designing for 3D printing requires a different approach compared to traditional manufacturing methods.

Applications:

- Manufacturing and production- 3D printing is increasingly being used for manufacturing and production of end-use parts, especially in industries such as aerospace, automotive, and healthcare. It enables the production of complex geometries and custom parts that are difficult or impossible to achieve with traditional manufacturing methods.

- Automotive and aerospace- The automotive and aerospace industries use 3D printing for prototyping, tooling, and manufacturing of lightweight components. It helps reduce weight, improve fuel efficiency, and optimize performance.
- Education and research- 3D printing is used in education and research for creating models, prototypes, and visual aids. It helps students and researchers visualise complex concepts and ideas in a tangible form.
- Rapid prototyping- One of the earliest and most common uses of 3D printing is in rapid prototyping. It allows companies to quickly and cost-effectively create physical prototypes of products for testing and validation before mass production.

Future scope:

- Advanced materials- Researchers are continuously developing new materials for 3D printing, including metals, ceramics, and composites. These materials offer enhanced properties such as strength, durability, and conductivity, opening up new possibilities for applications in the aerospace, automotive, and electronics industries.
- Mass customization- 3D printing enables mass customization of products, allowing for the creation of bespoke items tailored to individual customer preferences. This could revolutionize industries such as fashion, footwear, and consumer goods.
- On-demand manufacturing- The ability to quickly and cost-effectively produce custom parts on demand is reshaping the manufacturing landscape. 3D printing can reduce lead times, inventory costs, and waste, making it an attractive option for lean manufacturing.
- Sustainability- As environmental concerns grow, there is a focus on developing more sustainable 3D printing materials and processes. This includes using bio-based materials and recycling methods to reduce the environmental impact of 3D printing

Expectations from the team:

The goal is to create a 3D printing machine that addresses these limitations. By carefully considering the design requirements, select the appropriate materials, and follow best practices for 3D printing to ensure a successful outcome. The machine should have a large build volume to accommodate a wide range of print sizes and should be capable of printing intricate and complex geometries with high precision.

MECH03: Writing machine for physically disabled

A writing machine for physically disabled individuals is a specialized device designed to assist people with limited mobility or dexterity in writing and communication tasks. This machine typically features a user-friendly interface and customizable settings to accommodate a variety of needs and preferences. The machine's design focuses on accessibility, with large, easy-to-press buttons or switches that can be operated using minimal physical effort.

Past Methodology:

In the past, designing a writing machine for physically disabled individuals typically involved a user-centred approach, beginning with a needs assessment to understand users' specific challenges. Prototypes were developed iteratively based on user

feedback and usability testing, aiming to improve accessibility and user experience. Collaboration with experts in assistive technology and adherence to accessibility guidelines ensured the machine's design was informed by best practices. Technologies were selected based on users' abilities, and safety and reliability were paramount in the design process.

Available solution:

Several solutions are available for individuals with physical disabilities who need assistance with writing. These include specialized writing aids such as ergonomic pens and pencils, adaptive grips, and weighted pens that require minimal pressure to write. Voice recognition software and speech-to-text technology can also be helpful for individuals who have difficulty with traditional writing tools. For more complex needs, there are advanced communication devices that combine text-to-speech and speech-to-text capabilities, along with customizable interfaces and input methods tailored to the user's specific needs

Current issues and limitations:

- Limited customization- Many off-the-shelf writing aids have limited customization options, making it challenging to meet the specific needs of individuals with unique requirements.
- High cost- Specialized writing aids and assistive technologies can be expensive, making them inaccessible to individuals with limited financial resources.
- Maintenance and durability- Some writing aids may require regular maintenance or have durability issues, particularly with frequent use.
- Complexity- Some advanced communication devices with text-to-speech and speech-to-text capabilities can be complex to set up and use, requiring training and ongoing support.

Applications:

- Education- Writing aids can support students with physical disabilities in taking notes, completing assignments, and participating in classroom activities, enhancing their learning experience and academic performance.
- Workplace- Writing aids enable individuals with physical disabilities to participate more fully in the workforce by assisting with tasks such as writing reports, emails, and other documents, thereby promoting independence and productivity.
- Communication- For individuals with severe physical disabilities who cannot communicate verbally, writing aids with text-to-speech capabilities can serve as a vital communication tool, allowing them to express their thoughts and needs effectively.
- Accessibility- Writing aids contribute to making information and communication more accessible to individuals with physical disabilities, promoting inclusivity and equal participation in society.

Future scopes:

- Improved portability and connectivity- Future writing aids are expected to be more portable and seamlessly integrated with other devices and software, enabling users to write and communicate across various platforms and environments.

- Gesture and motion control- Writing aids that utilize gesture and motion control could allow users to write and navigate interfaces without physical contact, providing new avenues for interaction and accessibility.
- Enhanced customization- Future writing aids are likely to offer even greater customization options, allowing users to tailor the interface, input methods, and output settings to their specific needs and preferences.
- Inclusive design practices- Continued focus on inclusive design practices will ensure that future writing aids are accessible to individuals with a wide range of physical disabilities, promoting inclusivity and equal participation.

Expectations from the team:

Design and develop a writing machine for physically disabled individuals featuring a user-friendly interface, ensuring that they are effective, intuitive, and comfortable to use such that they can be operated using minimal physical effort. The machine should also be adjustable to accommodate a range of physical disabilities, including limited dexterity and mobility.

MECH04: A portable uroflowmeter

A uroflowmeter is a medical device used to measure and analyse urine flow rate. It typically consists of a container into which the patient urinates, connected to sensors or other measuring devices that record the flow of urine. Uroflowmetry, the procedure performed using a uroflowmeter, is commonly used in urology to diagnose conditions such as urinary obstruction, overactive bladder, and other urinary tract issues. The data collected by the uroflowmeter can provide valuable information about the patient's urinary function.

Past Methodology:

In the past, measuring and analysing urine flow rates were primarily manual and less sophisticated compared to modern methods. Historically, uroflowmetry involved patients urinating into a simple container with volume markers, and the time taken to empty the bladder was measured using a stopwatch. This manual approach was labour-intensive, and the accuracy of the measurements depended heavily on the skill of the healthcare provider.

Available solution:

Currently, uroflowmeters typically consist of a collection container, a flow sensor, and a digital display or recording device. Some uroflometers are designed for standalone use, while others are integrated into larger urodynamic systems for comprehensive urological testing.

Current issues and limitations:

- Accuracy and calibration- Ensuring the accuracy of uroflowmetry measurements can be challenging. Calibration of the flow sensors and regular maintenance of the equipment are crucial for reliable results. Variability in calibration and sensor performance can lead to inaccuracies in flow rate measurements.
- User variability- The accuracy of uroflowmetry measurements can also be influenced by factors such as user technique and patient cooperation. Inconsistent voiding patterns or improper positioning during the test can affect the results.
- Patient factors- Certain patient factors, such as age, gender, and medical conditions, can impact the results of uroflowmetry. For example, elderly patients or those with neurological disorders may have different voiding patterns that can affect the interpretation of the results.
- Cost and accessibility- High-quality uroflowmeters can be expensive, limiting their availability in some healthcare settings. This can restrict access to uroflowmetry testing for patients in certain regions or healthcare facilities.

Applications:

- Diagnosis of Lower Urinary Tract Symptoms- A uroflowmeter is commonly used to evaluate patients presenting with symptoms such as weak stream, hesitancy, and incomplete bladder emptying.
- Monitoring treatment response- Uroflowmeter can be used to monitor the effectiveness of treatment interventions for urinary tract conditions. Changes in flow rate and pattern over time can indicate the response to medications or surgical procedures.
- Research and clinical trials- It is used in research studies and clinical trials to evaluate new treatments, compare treatment outcomes, and investigate the underlying mechanisms of urinary tract conditions.
- Paediatric urology- Uroflowmeter is used in paediatric urology to assess urinary function in children with congenital abnormalities, neurogenic bladder, or other urological conditions. It helps in diagnosing and managing these conditions in paediatric patients.

Future scopes:

- Smart uroflowmeters- Integration of uroflowmeters with smart technology, such as Bluetooth connectivity or smartphone apps, to enable remote monitoring and real-time data analysis. This could improve patient convenience and enable healthcare providers to track urinary function more effectively.
- Miniaturisation and wearable devices- Development of miniaturized uroflowmeters that can be worn discreetly and comfortably, allowing for continuous monitoring of urinary function in ambulatory settings. This could be particularly beneficial for patients with chronic conditions requiring long-term monitoring.
- Precision medicine- Integration of uroflowmetry data with genetic, molecular, and clinical data to enable personalized treatment approaches based on individual patient characteristics. This could lead to more targeted and effective treatments for urinary tract conditions.

Expectations from the team:

Design and develop a prototype uroflowmeter capable of accurately measuring the flow rate of urine in real time for potential use in clinical settings. The uroflowmeter should be user-friendly, reliable, and cost-effective, providing healthcare professionals with valuable data for diagnosing and monitoring urinary conditions such as urinary tract obstruction, urinary retention, and urinary incontinence.

MECH05: Plastic recycling system

Plastic recycling machinery is essential for converting plastic waste into reusable materials, contributing to environmental sustainability. This machinery typically involves shredding or granulating the plastic waste to increase surface area, sorting it based on type and colour, washing to remove contaminants, and drying to eliminate moisture. The plastic is then melted and extruded into pellets or flakes, which can be used as raw material for manufacturing new plastic products. This process helps reduce the need for virgin plastic production and minimizes plastic pollution in landfills and oceans, making it a critical component of the circular economy.

Past Methodology:

In the past, plastic recycling often involved manual sorting and processing, which was labour-intensive and time-consuming. Workers would sort through plastic waste by hand, separating different types and colours of plastic. The plastic would then be cleaned, dried, and melted down using simple machinery. However, this method had limitations in terms of efficiency and scalability, and it often resulted in lower-quality recycled plastic.

Available solution:

There are several available solutions for plastic recycling machinery, ranging from small-scale machines suitable for startups and communities to large industrial systems for high-volume recycling operations. These solutions often include shredders, granulators, sorting machines (such as optical sorters and air classifiers), washing and drying equipment, extruders, and pelletizers.

Current issues and limitations:

- Contamination- Contamination of plastic waste with other materials, such as food residue or non-recyclable plastics, can affect the quality of the recycled plastic and the efficiency of the recycling process.
- Complexity of plastics- The wide variety of plastic types and formulations makes it challenging to recycle all plastics efficiently. Some plastics are more easily recycled than others, leading to limitations in the types of plastic that can be effectively processed.

- Energy consumption- The recycling process, especially the melting and extrusion stages, requires significant energy input, which can impact the overall environmental footprint of the recycling process.
- Cost- The cost of plastic recycling machinery and equipment can be prohibitive for some businesses and organizations, particularly smaller operations or those in developing countries.

Applications:

- Packaging- Recycled plastic is commonly used in the production of packaging materials such as bottles, containers, and bags.
- Construction- Recycled plastic can be used in construction applications, such as in the manufacture of pipes, flooring, and insulation materials.
- Automotive- Recycled plastic is used in the automotive industry for parts such as bumpers, interior trim, and under-the-hood components.
- Infrastructure- Recycled plastic is used in the construction of roads, bridges, and other infrastructure projects.

Future scopes:

- Advanced sorting technologies- Continued advancements in sorting technologies, such as AI-powered robotics and hyperspectral imaging, will improve the efficiency and accuracy of plastic sorting, enabling the recycling of a wider range of plastics.
- Chemical recycling- Chemical recycling technologies, which break down plastics into their molecular components for reuse as feedstock, hold promise for recycling plastics that are currently difficult to recycle mechanically.
- Bioplastics and biodegradable plastics- The development of bioplastics and biodegradable plastics will create new challenges and opportunities for plastic recycling machinery, as these materials require specialized recycling processes.

Expectations from the team:

Design and fabricate a plastic recycling system that meets your specific needs and contributes to the sustainable management of plastic waste. The system should be cost-effective, energy-efficient, and scalable, allowing for implementation in a range of settings, from small-scale recycling facilities to large industrial operations. Consider factors such as the types of plastic you will be recycling, the desired output capacity, and any unique features or innovations you want to incorporate.