AI Based Generative Design of Hydro Power Plants

Optimizing Hydropower with AI : A Sustainable Energy Evolution

PRESENTED BY

VISHAAL S
PAVITHRA R
DHAARANI K

Agenda

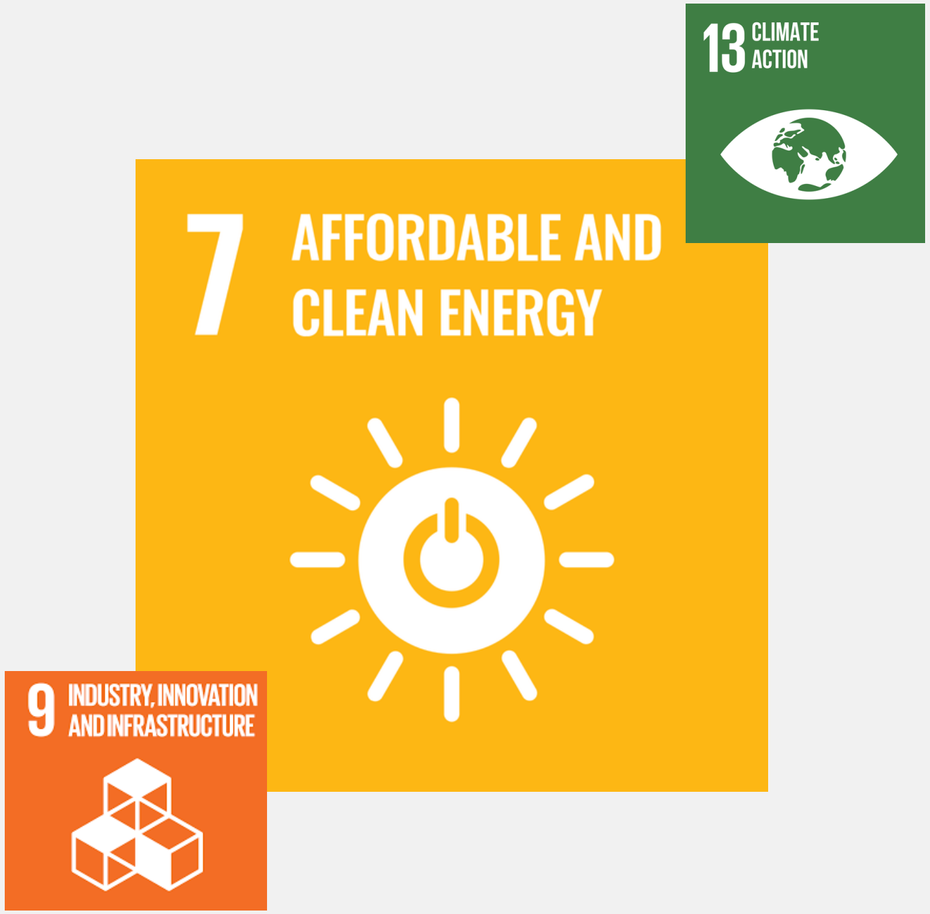
ABSTRACT

This project proposes the use of integration of Artificial Intelligence (AI) techniques into the generative design process of hydro power plants, aiming to optimize their performance and minimize ecological footprints. The proposed AI-based generative design approach offers several advantages. Firstly, it significantly reduces the time and resources traditionally required for the design phase by automating complex calculations and simulations. Secondly, it enhances the precision and accuracy of the designs by considering a multitude of variables and their interconnections, which are often beyond the scope of manual analysis. Thirdly, the approach promotes sustainability by prioritizing eco-friendly designs, minimizing the ecological impact on surrounding ecosystems and communities. Fourthly, it will reduces the manpower by automating repetitive tasks such as data analysis and simulations, significantly reducing the need for human intervention.

PROBLEM STATEMENT

The hydropower sector faces great challenges in designing and upgrading hydropower plants in a sustainable and effective manner. These issues include inefficiencies in design, cost overruns, negative environmental impacts, difficulties in data integration, and lack of creativity. The solution to this problem is to create and implement an AI-based generative design system specifically for hydroelectric power plants. The primary goal is to enhance efficiency, cost-effectiveness, and environmental sustainability in the development of hydro power plants. It involves customizing designs to meet project-specific requirements, whether the project is large or small in scale. This innovative approach aims to streamline project development, reduce costs, and minimize manual iterations through data-driven automation.

SDG GOALS



- The project "AI Based Generative Design of Hydro Power Plants" is relevant to SDG Goal 7: Affordable and Clean Energy. The project aims to ensure access to affordable, reliable, sustainable, and modern energy for all.
- The project "AI Based Generative Design of Hydro Power Plants" is relevant to SDG Goal 9: Industry, Innovation and Infrastructure. The project aims to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.
- The project "AI Based Generative Design of Hydro Power Plants" is relevant to SDG Goal 13: Climate Action. The project aims to reduces reliance on fossil fuels, leading to a significant reduction in greenhouse gas emissions and sustainable infrastructure development.

WORK FLOW

8 STEP PROCESS

1.DATA COLLECTION
Take the real time data from river flow rates, reservoir levels, weather conditions and power generation data

2.DATA PREPROCESSING
Raw sensor data needs preprocessing to clean and format the data

3.DATA STORAGE
Store the preprocessed data in a structured format

4.DATA INTEGRATION
Integrate this data into a single dataset for training and inference

5.FEATURE EXTRACTION
1.Image data-CNN,
2.To determine how river flow rates correlate with water level measurements-Linear Regression
3.To measure the water quality measurements as “acceptable”,”marginal”, or “unacceptable”-Decision Trees

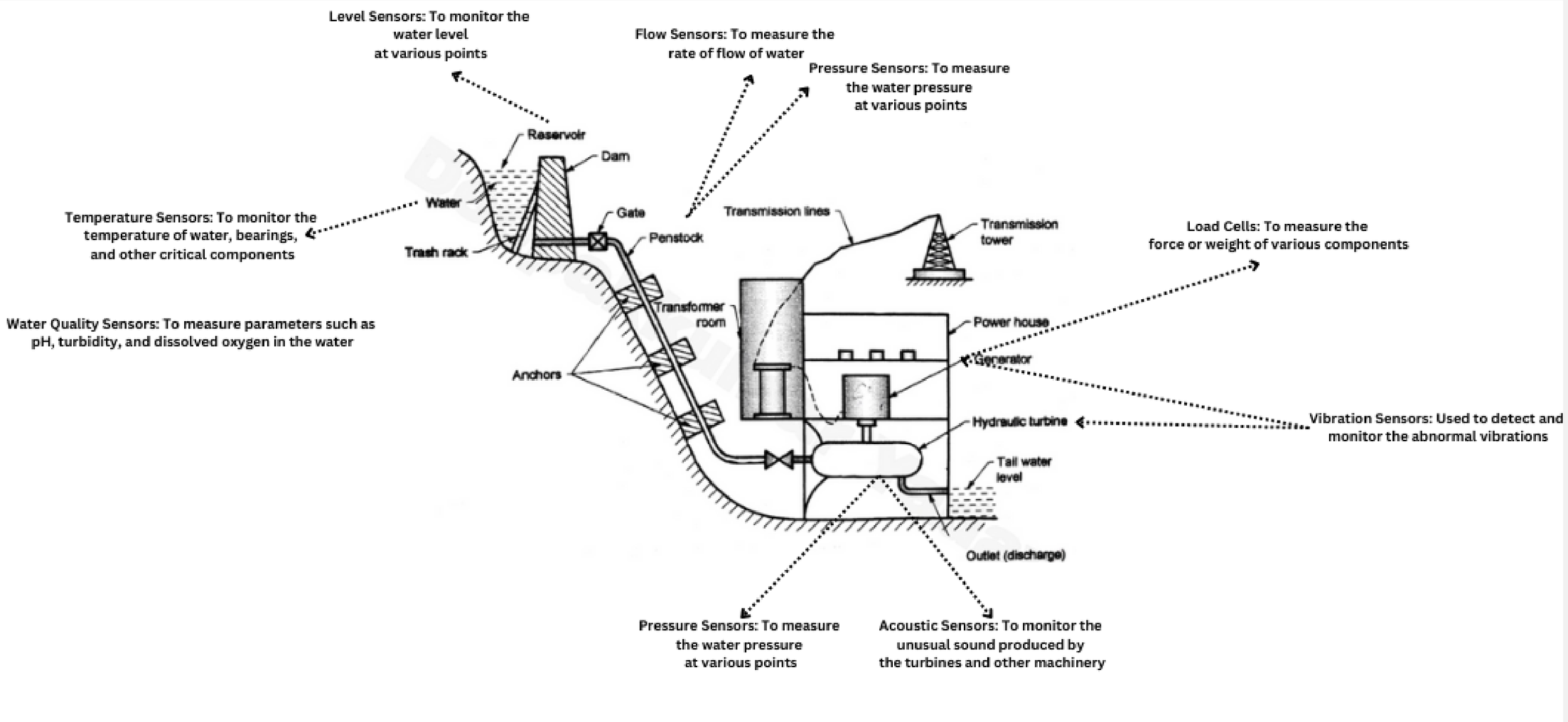
6.DATA SPLITTING
Split the data into training, validation and test sets

7.TRAINING
Train the AI model based on these test sets

8.DEPLOYMENT
Monitor the performance of the ai model in the real-world setting

BACK TO AGENDA

PROPOSED SYSTEM



BACK TO AGENDA

TECHNOLOGY STACK

- **Language:** Python.
- **IDEs:** Google Colab
- **Libraries:** Tensorflow, Keras, Pytorch.
- **Hardware Requirements:** A system with high GPU and processor.
- **Amazon S3** (store and manage large data efficiently)
- **Geographic Information System** (for handling geospatial data related to hydro power plant locations and environmental impact)

MODEL SELECTION APPROACH

- **Model:** Regression, Decision Trees, Random Forest, Gradient Boosting, Neural Networks, Computational Fluid Dynamics (CFD), Finite Element Analysis (FEA)
- **Training Strategies –**Data augmentation(to increase dataset size)

OBJECTIVES

BACK TO AGENDA

FEATURES

- Capable of processing large datasets related to hydrology, geology, environmental factors, and engineering constraints.
- Use of machine learning algorithms to learn from historical data and optimize the design process and can be employed for predictive modeling and pattern recognition.
- Use of simulation tools to model the behavior of hydro power plants under different conditions.
- Includes simulation tools for behavior modeling and visualization for comprehensibility.
- Collaborative tools enable real-time teamwork, while cost analysis modules assess economic viability.
- Scalability, security measures, and a user-friendly interface are crucial components which ensuring a comprehensive and efficient approach to sustainable hydro power plant design.

NOVELTY

- Site Specific Optimization
- Flow simulation
- Maintenance Scheduling
- Energy Storage Integration
- Environmental Impact Reduction
- Cost Optimization

Real-time data analysis and optimal plant performance.

Tailoring hydro power plant designs to meet the specific requirements

WOW FACTORS

Ability to adjust operational parameters

Complex AI and Machine Learning methods

Availability of methods and skills required to implement

DEPENDENCIES

Obtaining data in real-time

BACK TO AGENDA

EXISTING SYSTEM

ADVANTAGES

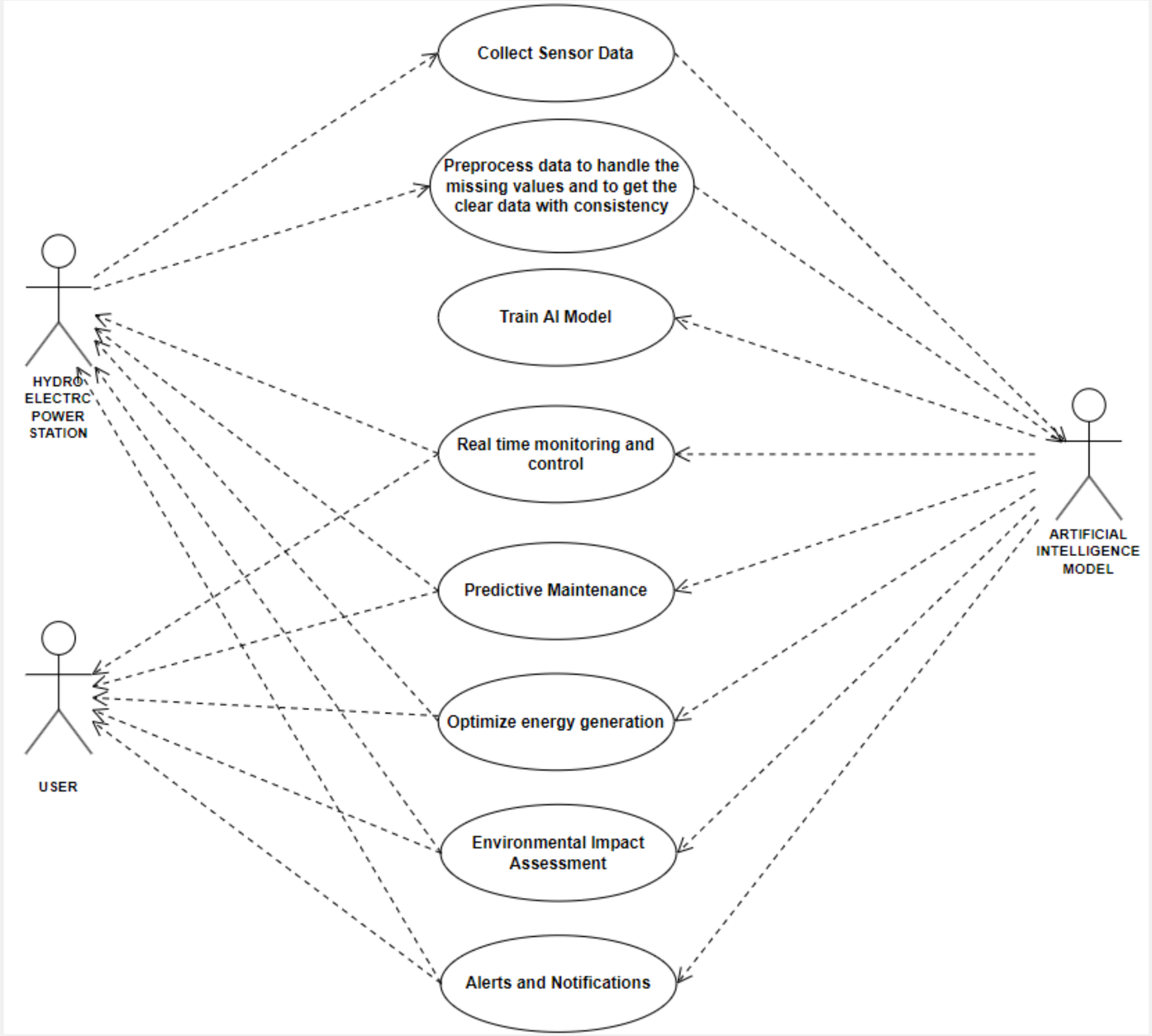
1. Predict water intake in the dam over a weekly range (around 10 days) using rainfall forecasts for the area in which the dam is located
2. Optimize the allocation of reservoir-stored water resources used for power generation over a weekly range using forecasts of the water intake in the dam, market supply and demand, and market rates over an extended period of time
3. Formulate optimized next-day power generation plans (in 30 minute increments) using forecasts of market supply and demand, and market rates

DISADVANTAGES

1. They did not have the system to monitor the states of penstock and turbine.
2.They do not have the CNN model to analyse the corrosion that will be happen in the penstock and turbines.
3.They don't have the flow and pressure sensor to predict the pressure and flow of water.

BACK TO AGENDA

USE CASE



BACK TO AGENDA

BUSINESS MODEL

Key partners

- Hydroelectric power plant operators/owners
- Engineering and Construction Firms
- Renewable Energy Organization
- Research Institutes and Universities
- Government Agencies and Regulators
- Data Providers and Analytics Companies
- Environmental and Sustainability Organizations
- Technology and Software Providers
- Investors and Venture Capitalists
- Customers and End Users

Key activities

- Industry Research and Understanding
- Identify Target Customers
- Value Proposition Development
- Engage in Industry Events
- Collaborate with Industry Leaders
- Data Security and Privacy
- Long-Term Relationships
- Scalability and Customization

Key resources

- Human Resources
- Data
- Computing Resources
- Software Tools
- Financial Resources
- Market Research and Marketing Resources
- Testing and Validation Resources
- Continuous Research and Development

Channels

- Market Research
- Online Presence
- Content Marketing
- SEO Optimization
- Email Marketing
- Networking and Industry Events
- Customer Testimonials and Case Studies
- Webinars and Workshops
- Referral Programs
- Social Proofs
- Continuous Improvement
- Partnership and Alliances
- Demonstrations

Customer relationships

- Initial Engagement
- Project Onboarding
- Regular Updates
- Scheduled Meetings
- Customer Support
- Feedback Sessions
- Performance Reviews
- Strategic Planning
- Ad Hoc Communication
- Product Updates
- Community Engagement

Cost Structure

- Cloud Service Costs: 9000
- Development Costs: 10,000 - 15,000
- Hosting Cost: 1,00,000
- Testing: 50,000
- Marketing Costs: 50,000 - 1,00,000

Customer segments

- **Hydro Power Plant Developer** seek AI solutions to optimize the design process, reduce costs, and improve efficiency.
- **Hydro Power Plant Operators** are interested in AI-based solutions for optimizing operational efficiency, predictive maintenance, and maximizing energy generation from their plants.
- **Regulatory Bodies and Government Agencies** overseeing the hydro power industry may use AI solutions to assess and ensure compliance with environmental and safety regulations.
- **Environmental and Sustainability Organizations** are interested in AI-based generative designs that minimize ecological footprints in hydro power plant construction and operation.

Key propositions

- Efficient Design Optimization
- Real Time Monitoring and Alerts
- User-friendly Interfaces
- Data Security and Privacy
- Transparent Pricing

Revenue Streams

- Subscription Plans and Customization Fees
- Maintenance and Support Agreements
- Cloud-based Services
- Performance Based Pricing
- Maintenance and Predictive Analytics

BACK TO AGENDA

IMPLEMENTATION

Fig 1: Water Quality Analysis Dataset

	ph	Hardness	Solids	Chloramines	Sulfate	Conductivity	Organic_carbon	Trihalomethanes	Turbidity	Potability
0	NaN	204.890455	20791.318981	7.300212	368.516441	564.308654	10.379783	86.990970	2.963135	0
1	3.716080	129.422921	18630.057858	6.635246	NaN	592.885359	15.180013	56.329076	4.500656	0
2	8.099124	224.236259	19909.541732	9.275884	NaN	418.606213	16.868637	66.420093	3.055934	0
3	8.316766	214.373394	22018.417441	8.059332	356.886136	363.266516	18.436524	100.341674	4.628771	0
4	9.092223	181.101509	17978.986339	6.546600	310.135738	398.410813	11.558279	31.997993	4.075075	0

Implementation Video

https://youtu.be/a9rptmA4qxc?si=SiB9F1entP-_2tmc

Fig 2: Prediction of corrosion in YOLOv5

Fig 3: Accuracy Score of Water Quality Model by using various algorithms

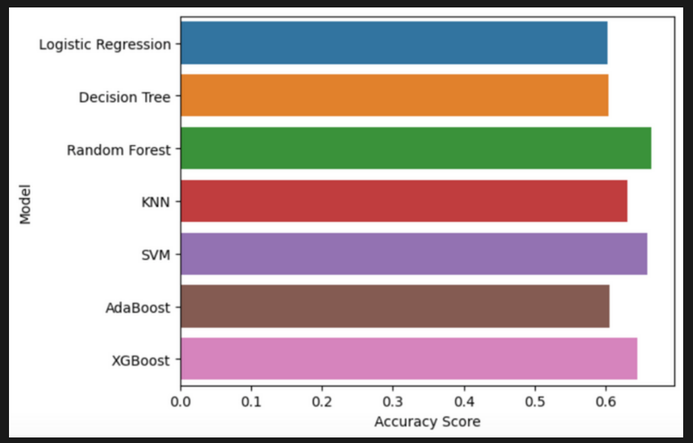


Fig 4: Enhancement of video in MATLAB

BACK TO AGENDA

CONCLUSION

The AI-based generative design system for hydro power plants represents a groundbreaking approach to sustainable energy solutions. By integrating advanced technologies like artificial intelligence and data analytics, the project optimizes energy output, minimizes environmental impact, and ensures economic viability. Through detailed data analysis and real-time monitoring, the system enhances hydro power plant efficiency and fosters climate resilience. Its emphasis on collaboration, user-friendly interfaces, and scalability highlights its adaptability and accessibility. Furthermore, by promoting public awareness and sustainable practices, the project contributes significantly to a greener and more sustainable energy future.