Università degli Studi di Padova

Dipartimento di Ingegneria dell'Informazione

Exploring AI Techniques for Effective Monitoring of Aquatic Toxicity

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Artificial intelligence presentation

Academic year 2022/23

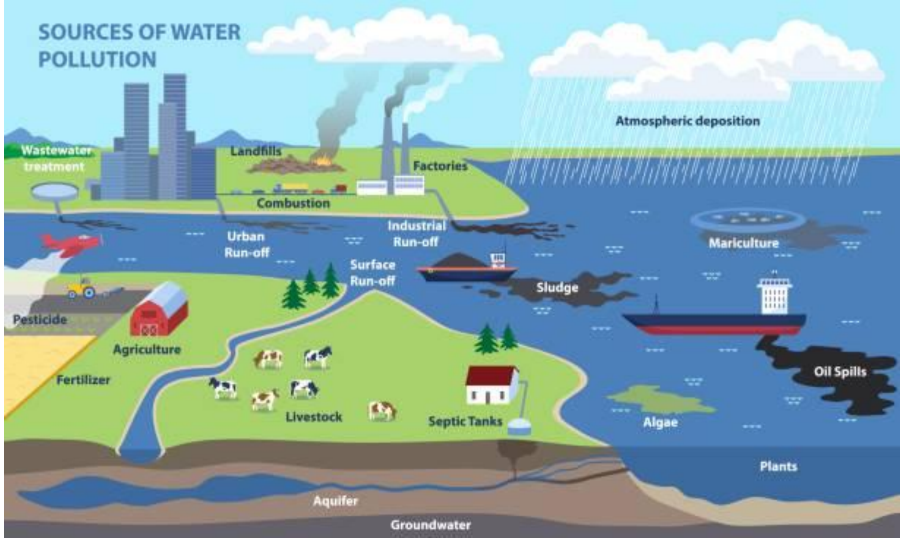
Outline

1. Introduction
2. Our Analysis
3. Different usages of AI models in real scenarios
4. Conclusion

1. Introduction

Aquatic toxicity is a pressing concern that affects the health of our oceans, rivers, and other water bodies. It poses a significant threat to marine ecosystems, biodiversity, and ultimately, to our own well-being.

The need to monitor and mitigate aquatic toxicity has a crucial importance.



1. Introduction

AI-driven systems can provide real-time analysis, early detection of toxic events, and efficient identification of toxic substances and their sources.

Why have we chosen this topic?

- Highlight the issue
- Explore the applications and benefits of AI in these domain
- Present a status update on the research conducted in this area

Water quality and social impact

Key Aspects:

- wildlife and biodiversity conservation
- managing environmental issues
- managing water economics implication
- managing social impact/well-being

AI's Role:

- Effective monitoring and management
- Reduce costs of monitoring
- Enhancing efficiency and accuracy
- Timely detection of water quality issues

2. Our Analysis

Updating the research of Joshua O. Ighalo et al.

Artificial Intelligence for Surface Water Quality Monitoring and Assessment: A Systematic Literature Analysis

- Objective: Update research, provide insights, and highlight the need for standardized guidelines
- Methodology: Analyze model frequency and accuracy using R^2
- Approach: Provide a comprehensive overview
- Model Diversity: Wide range of models used for water quality assessment.
- Data Sources: Utilize new elements from Web of Science and SPUSU.

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2. Our Results

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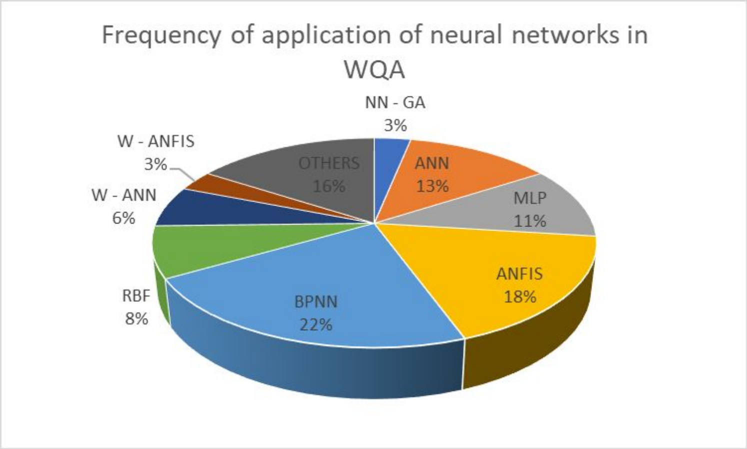
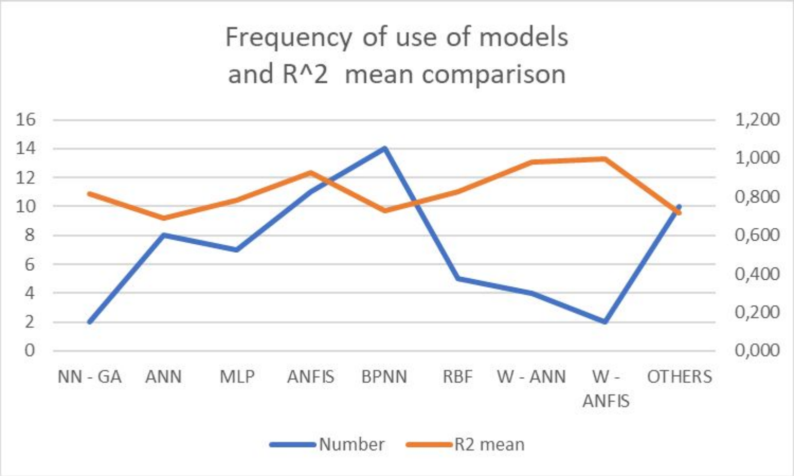




- Back Propagation Neural Network is widely utilized
- No single model stands out for exceptional performance based on frequency of use

3. Different usages of AI models in real scenarios

Now will follow a brief description of different usages of AI models in some real scenarios

- Water treatment for optimization and automation of adsorption processes
- Aquatic toxic analysis by monitoring fish behavior
- Models for Accurate Estimation of Groundwater Nitrate Concentration
- Predicting acute aquatic toxicity of structurally diverse chemicals in fish using artificial intelligence approaches

Models for Accurate Estimation of Groundwater Nitrate Concentration

Goals:

- Model nitrate concentration using AI in the Marvdasht watershed, Iran
- Aid in managing and improving groundwater quality

Materials and Methods:

- AI models evaluated: Cubist, SVM, RF, and Bayesian-NN
- Dataset: Groundwater nitrate concentrations from 67 wells
- Features used: Geo-environmental variables (elevation, slope, rainfall, etc.)
- Evaluation tools: R2, RMSE, MAE, and NSE

Results:

- RF model performed the best:
  - R2: 0.89

Conclusion:

- Nitrate pollution in groundwater is a growing concern
- **AI models effectively predict nitrate water pollution**
- RF model outperformed other models
- Regular monitoring and farmer education crucial for prevention

Predicting acute aquatic toxicity of structurally diverse chemicals in fish using artificial intelligence approaches

Goals:

- Construct probability function-based neural network models
- Compare them with other non-linear models

Materials and Methods:

- Different AI techniques involved (PNN, GRNN, MLPN, RBFN, SVM, GEP, DT)
- Classification (predict toxicity classes) and regression (acute toxicity by means of -log LC_{50})
- To develop the models fathead minnow database (EPA) was used and also other different data sources for understanding if the models are appropriate for working well in noisy environments
- Several evaluation techniques for classification and regression

Results:

- Classification with two classes: with more than 89% of accuracy, sensitivity and specificity in the complete dataset, PNN achieved the best results.
- Classification with four classes: with 89.44%, 82.10% and 93.02% respectively, PNN performed slightly better then others.
- For regression task, GRNN achieved the best result with 0.35 of MAE, 0.51 of RMSE, 0.51 of SEP, -0.02 of bias, 0.85 of E_f and 0.926 of R.

Conclusion:

- All the models achieved good performance, with PNN performing relatively better in classification and GRNN in the regression task.
- The PNN and GRNN models were tested with external datasets, and they performed well
- Thus, they are appropriate for acute toxicity prediction of new chemicals and can be used as effective tools in regulatory toxicology decision making.

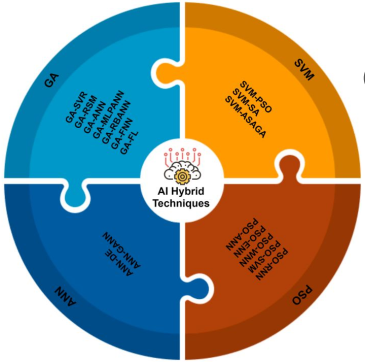
Water treatment for optimization and automation of adsorption processes

Goals:

- Treatment and reuse of wastewater offer solution to problem of access to clean drinking water, accentuated by water pollution
- AI is expected to save 20 to 30% of operational expenditures by decreasing the cost and optimizing the usage of the chemicals

Materials and Methods:

- Various techniques: ANNs, k-NN, DT, RF, SVM, hybrid, …



Results:

- AI improves removal of dyes, heavy metals, organic compounds, drugs, pesticides,… from water
- Hybrid techniques more effective in predicting process → reduction in energy and operational cost
- Some studies also predicted simultaneous removal of multi-pollutants from water with the aid of AI

Conclusion:

- AI tools can be used to predict performance of water treatment reducing experimental costs

Paper 4

Aquatic toxic analysis by monitoring fish behaviour

Goals:

- Use behavioral monitoring of indicator species instead of physicochemical parameters for detect toxicants in water
- Detect unknown toxicants in long-term monitoring

Materials and Methods:

- Sensors for physicochemical monitoring
- For behavioral monitoring:
  - cameras (2D/3D)
  - CV for tracking
  - DL (starting stage)

Results:

- Monitor behaviour changes possesses features like high stability and reliability, easy maintenance, and low operating cost
- Real-time observation adopted because permits early stage detection of risks and better use of storage, but requires hardware and high performance algorithms

Conclusion:

- Machine learning algorithms are superior in predicting aquatic toxicity but computational expensive operations involved for real-time data analysis

4. Conclusion

- Social impact of water quality management extends beyond environmental concerns
- By promoting interdisciplinary research and arguments in this field:
  - pave the way for a sustainable future where clean water is accessible to all
  - ecosystems thrive
  - communities flourish
- Justified considering that the availability of clean water is a critical sustainable development goal
- NNs in water quality monitoring and assessment is a relatively young research area, so they could have a bright future