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Data-driven artificial intelligence–based streamflow projections under climate change: Review of methods and application for Melbourne's supply system

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Abstract: Streamflow is one of the most critical and challenging inputs for water resource modelling, planning, and decision-making. A better streamflow forecast establishes wiser and more accurate future decisions under population increase and climate change/variability. Data-driven artificial intelligence (DDAI)–based prediction has gained much attention, especially in recent years, because of its power and flexibility compared to traditional approaches. In hydrology, streamflow forecasting is one of the areas that took advantage of DDAI-based forecasting, given the weakness of the old approaches (e.g. physical-based approaches). Given that many different techniques and tools have been used for streamflow forecasting, it is necessary to explore them. Climate change impacts the hydrological balance. This imbalance brings more uncertainties, including non-stationary conditions, into the system's variabilities. This makes long-term streamflow forecasting more challenging and complex, given that there are significant uncertainties in climate change projection from General Circulation Models (GCMs). Temperature is the only variable that has enough confidence in the GCMs projections.

This proceeding reviews the last ten years (2011 to 2022) applications of DDAI in streamflow prediction, including machine learning algorithms, methods for pre-processing the data, and optimising or enhancing the machine learning approaches. We also explore applying one of the DDAI-based techniques (reviewed in this work) for long-term streamflow forecasting under climate change conditions.

Artificial intelligence (AI) is a relatively new science in which programs/machines experience, learn, act, and achieve goals using the gained intelligence similar to humans. Machine learning (ML) is one of the significant parts of AI that brings the algorithms of automatic learning, improvements, and increased chance of success (Hrnjica and Danandeh Mehr 2020). ML performs a skilful job by training in which the learning (intelligence) is based on statistical approaches (Mohammed et al. 2016). Hydrological modelling and forecasting use the aspects of AI for enhancing prediction.

We investigated creating a DDAI-based model, a hybrid model of Particle Swarm Optimization and Support Vector Machine (PSO-SVM) that predicts streamflow using temperature and stochastically generated data from historical streamflow. For calibrating and verifying the model, historical streamflow and mean maximum temperature of the study area were collected. The model is trained and verified to project the future streamflow using historical inflow and future temperature (from GCMs) as input time series. The case study for this research is four catchments: Thomson, Upper Yarra, O'Shannassy, and Maroondah (Watts River and Graceburn Creek), in Victoria, Australia.

This study shows that using improved machine learning techniques (hybrid model) can build a predictive model that projects future streamflow scenarios based on the current streamflow and future temperature. The predictive model then uses sequences from the stochastic streamflow to project a range of plausible future streamflow under climate change conditions.

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