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Automatic identification and placement of measurement stations for hydrological discharge simulations at basin scale

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In the past 15 years hydroinformatics has substantially increased the use of computational intelligence techniques for water distribution network, modelling, and prediction purposes.

An application of these technologies is proposed in this study as an advanced algorithm tool to analyze a hydro-meteorological dataset, establishing a skill for numerical modelling, data collection, processing and quality checking.

Accurate forecasts of hydro-meteorological events are important to prevent and mitigate the effect of dangerous events such as floods or drought. To achieve these objectives, Politecnico di Milano developed a distributed physically based rainfall-runoff model (FEST-WB), which is daily used to generate runoff simulations and hydrological forecasts for nowcasting monitoring and as a civil-protection tool. It takes, as input, a set of observed meteorological data (solar radiation, precipitation, air temperature and relative humidity) collected by the ARPAP (Environment Protection Regional Agency of Piedmont) hydro-meteorological station network and MeteoSwiss, and it provides, as output, discharge forecasts in various hydrological basins. Although, the performance capability of the model dramatically depends on the model itself, it is a known fact that the choice of right measurement sites play a very crucial role in building quality models; on the other hand, reducing the amount of stations reduce their deployment and maintenance costs.

The aim of this study is to apply a set of optimization algorithms in order to identify the minimum number and position of weather stations able to provide correct predictions. This analysis is focused on the Toce river basin, an Alpine watershed, located in North-West of Italy, but the methodology can be extended to other Piedmont areas.
The whole set of measured data M are taken as input to provide a set of Pareto-optimal solutions. The configuration is described with a boolean vector where true indicates that the corresponding data is used, and false that it is not used. Using this definition of the solution space it is possible to apply various optimization algorithms such as genetics and simulated annealing. Iterating on a large set of possible configurations these algorithms provide the set of Pareto-optimal solutions, i.e. the number of measuring points is minimized while the forecasting accuracy is maximised. The identified Pareto curve is approximate, since the identification of the complete Pareto curve is practically impossible due to the large amount of possible configurations.

From the experimental results, as expected, we notice that a certain set of weather data are essential for hydrological simulations while other are negligible. Combining the outcome of different optimization algorithms is possible to extract a reliable set of rules to place measurement stations for forecasting monitoring.