Network analysis for inferring spatio-temporal predictive models in water demand consumption

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Time series pattern discovery is of great importance in a large variety of environmental and engineering applications, from supporting predictive models to helping to understand hidden underlying processes. While a wide range tools and techniques for time series analysis already exist, the increasing availability of massive data structures calls for new approaches for networked structures of time series [1,2].

This work proposes to approach multiple time series analysis of water consumption data. The information is arranged in a network composed by water sources and consumption nodes. The abstraction of a water distribution system (WDS) to a network analysis is approached by understanding water pipes (or set of pipes) as network links. Reservoirs, tanks, and water consumption points (or set of points forming district metered areas) are represented as network nodes. These nodes have different properties depending on the role they have on the water supply. Basic network analyses provide information regarding the most important link in the network or which the nodes stronger or weaker connected to water sources such as reservoirs and tanks. This prior information is based on graph-theoretic measures such as edge and node betweenness, k-shortest paths, and minimal spanning trees [3]. After approaching this graph-theoretic framework it is possible to have valuable network characteristics. This opens the possibility to know which network areas are strongly correlated between themselves or which links are the most important for meeting water demand requirements at every node.

The process continues by proposing a WDS division into district metered areas (DMA). Historical records of water demand are collected at each of these DMA and a multiple time series analysis is approached at several levels of resolution of the water demand time series. This varying resolution facilitates both extracting time series patterns and inferring network nodes relationships. The previous output is used as input of a neural network model from which are obtained predictive models. One of the main benefits this current proposal is to open the possibility to generate several water distribution scenarios; for example by taking into account disruption events or by considering metering failures. In addition, it makes possible to generate synthetic water demand values supporting a better performance of further water network simulation processes.

This study uses water demand data collected from operational DMAS in Franca, Brazil, as an extension of the previous case-study already analysed by the authors [4]. Water consumption data corresponds to metered data at the DMA' inlet every 20 minutes from May 2012 until December 2013. The results enhances previous approaches since provide a complete explanation of the effect in the water demand of hydraulic and environmental events, in addition to analyse how inputs impact on the time series at various levels of DMA aggregation until reach the whole network.

References

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