Digital Twin for Hydrocarbon Groundwater Plume Monitoring through Sensor Data Fusion

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Motivation

Leakage from refined product pipelines and underground storage tanks (Fig. 1) contributes 34,000 m^3/year of petroleum hydrocarbon contamination to land and groundwater resources in the USA alone[1]. The major components of petroleum hydrocarbons are benzene, toluene, ethylbenzene, and xylenes (BTEX) which can be harmful to the environment and pose significant health risks[2].

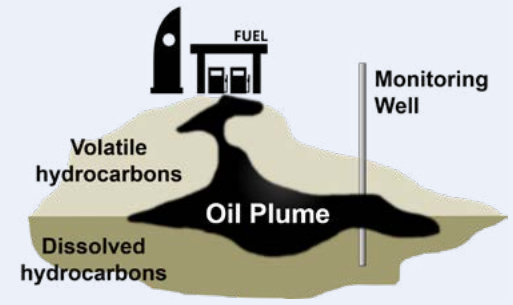


Fig.1 Oil Plume Conceptual Model

Currently, groundwater is monitored by quarterly or yearly sampling which provides low resolution data. The associated costs and potential health issues comprise a safety and environmental burden to groundwater sampling activities[3].

Research goals

The goal of this research is to realize the concept of Digital Twin through the development of a reliable and low-cost multi-sensor system together with a computational sensor fusion framework that would enable remote monitoring of BTEX in groundwater under varying conditions (Fig. 2). The Digital Twin concept allows the continuous update of the system in real time through a bidirectional flow of information[4], usually through sensors (Fig. 3).

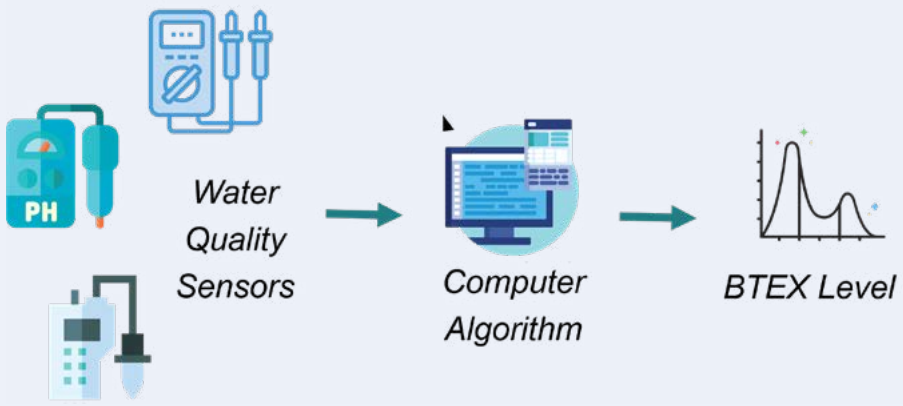
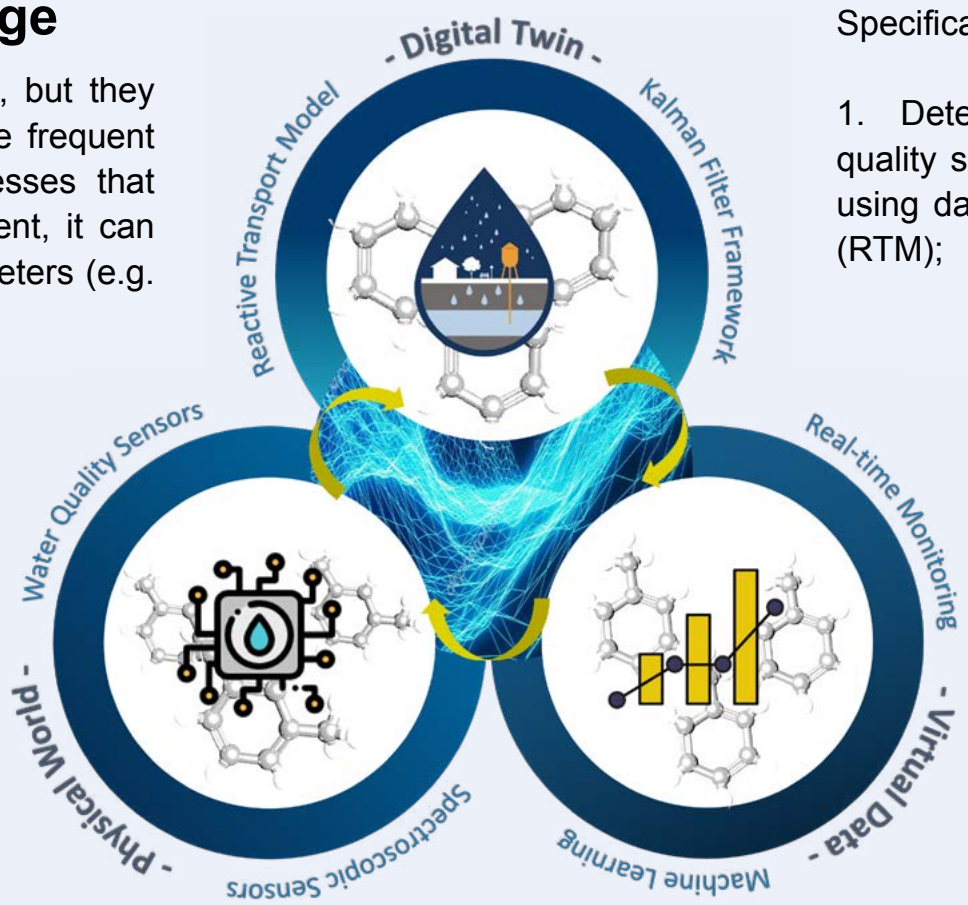


Fig. 3 Sensor Data Fusion Illustration

Technological challenge

Hydrocarbon sensors are available, but they are relatively expensive and require frequent maintenance. Based on the processes that are triggered following a spill incident, it can be inferred that water quality parameters (e.g. dissolved oxygen, oxidation-reduction potential, pH) can contain indirect information on the level of BTEX. These parameters can be monitored with low-cost sensors. However, the relationship with BTEX levels in groundwater has not been established yet.



Specifically, this research aims to:

1. Determine the correlation between water quality sensor data and BTEX concentration using data from reactive transport modelling (RTM);

2. Develop a Digital Twin based on the RTM using a Kalman filter-based framework with sensor data as input;

3. Validate the Digital Twin concept through laboratory experiments; and

4. Assess the suitability of the developed Digital Twin in real life applications by doing a field test.

Expected benefits

- Efficient groundwater monitoring
- Early detection and warning system
- Real-time estimation of pollutant

References

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[4] Jones, D. et al. (2020).CIRP J Manuf Sci Technol Vol 29, Part A, 36-52, ISSN 1755-5817, https://doi.org/10.1016/j.cirpj.2020.02.002