Evaluation of Expected Consequences of a Nuclear Power Plant Accident using Sequential Monte Carlo

Radek Hofman, Václav Šmídl
ÚTIA AV ČR, v.v.i., Pod Vodárenskou věží 4, 182 08 Praha 8
hofman@utia.cas.cz, smidl@utia.cas.cz

We are concerned with probabilistic evaluation of consequences of an incident for support of appointed decision makers. Specifically, we consider scenario with an accidental release of radioactive material from a nuclear power station into the atmosphere. In such a case, the decision makers are expected to make decisions about possible countermeasures such as iodization or evacuation of the population.

Key information that needs to be available in these situations are expected consequences of the release. For example, the expected map of the area where the absorbed radiation dose exceeds a predefined limit. Many existing software tools are capable of computing such estimates, however, most commonly in a deterministic way. In this paper we advocate the use of Bayesian approach, where all potential consequences are treated as random variables. Specifically, we focus on the sequential Monte Carlo techniques that represent all potential future realizations of the situation by a set of deterministic possibilities (called the particles). We show that this representation allows to answer various questions required by the decision makers.

Since we focus on the very early phase of a radiation accident, the proposed algorithm is supposed to work in a fully autonomous regime without any supervision. We demonstrate that such a tool can use the radiation measurements provided by a radiation monitoring network and significantly improve predictions of radiation situation by the means of data assimilation process. The system on-line gathers data from all the receptors around nuclear facility, combines it with forecast given by an atmospheric dispersion model and thus gradually improves the estimates of radiation situation. The system based on advanced methods of Bayesian filtering is capable of providing probabilistic answers regarding the release and its consequences, e.g. estimates of affected number of people and probability distributions of doses in inhabited areas. Moreover, the algorithm can be also used in the off-line regime, when it allows to address complex tasks such as positioning of measuring devices in order the maximize their usefulness in case of a release.

The algorithm and its benefits will be demonstrated on a simulated release from the nuclear power plant Temelin. We will show that even the current sparse radiation monitoring network surrounding the power plant can be successfully used for data assimilation purposes.