Description for the general public

Rule languages are used as the main logic-based reasoning tool in intelligent systems, especially in the field of knowledge representation. For many years special emphasis is being placed on their applications as database query languages where models admit finite domains only. In such cases, queries expressed in these languages, including the 4QL language coauthored by the grant leader, often enjoy acceptable data complexity. Applied rule languages of higher complexity, such as the well-known ASP language, though not guaranteeing tractability, also offer implementations efficient enough to be used in solving many non-trivial problems over instances with data sizes encountered in practice.

The main issues motivating the emergence of of knowledge representation formalisms and their further intensive development, are related to deficiencies of available information, like its incompleteness, uncertainty and potential inconsistencies. Nowadays, the major knowledge representation approaches can be divided into two more or less separate threads:

- symbolic/qualitative, based on (non-classical) logical inference, including non-monotonic, paracomplete and paraconsistent reasoning;
- quantitative, based on probabilistic/statistical and fuzzy inference.

Despite the effort towards this direction, the integration of symbolic and quantitative reasoning methods is still an important and intensively explored research question. Therefore, the main goal of the project is to enrich the 4QL and ASP languages by:

1. developing ASP and 4QL extensions, including their finitely many-valued versions;
2. integrating ASP with probabilistic reasoning;
3. developing of an object-oriented version of 4QL;
4. integrating ASP and 4QL.

The research is of theoretical nature, although we expect that it will be accompanied by prototype implementations as a result of MSc/PhD related research potentially complementing, but not included in the grant. Many challenges in the proposed research can be approached by extending the methods used for 4QL and ASP. In the proposed research a strong emphasis will be placed on developing algorithms for computing and querying models as well as on the complexity of the solutions developed.

Accepting additional logical values representing contradiction and ignorance, and grading logical values by numerical (e.g., probabilistic) or symbolic finitely ranged grades, substantially simplifies the approach since universal embeddings of many-valued formalisms into the classical two-valued ones, correct in all application areas, are not sought here. On the contrary, the aim is to develop tools for rule-based specifications of various embeddings, partial or total, in a context-dependent manner. Such a flexibility together with efficient computational solutions, has not been achieved so far.

The results of the research will therefore be applicable to efficient extensions of rule languages, complementing their development as well as significantly facilitating the design of autonomous intelligent systems, e.g., in robotics or multi-agent systems.