Chapter 7

Conclusion and Future Work

In this thesis, we have proposed a language based framework to represent and recognise motion patterns. We have presented a qualitative description language that helps us represent and recognise motion patterns. Using spatio-temporal continuity of binary qualitative relations, we have developed algorithms for handling noise in input data.

7.1 Contributions

We would like to enumerate the main contributions of this thesis below:

- We have chosen to use qualitative spatial relations to represent movement parameters. This brings motion pattern representation close to human cognition. Moreover, use of qualitative relations reduce the amount of information processing one needs to perform for motion pattern recognition.
- We have proposed a method of combining grammar based pattern recognition with qualitative spatial representation and reasoning. We have shown that using qualitative representation, it is possible to recognise a motion pattern among multiple objects using regular grammar.
- We have presented a method for learning a motion pattern automatically from real data and representing it in the form of a regular grammar.

- We have shown that noise in input can be handled using spatio-temporal continuity of qualitative relations that are used to represent movement parameters.
- We have proposed a Qualitative Description Language (QDL) for handling issues such as hierarchy, multiplicity of objects and concurrency.
- We have presented an application of the framework in GIScience by showing how **QDL** code segments can be written for representation and recognition of a standard taxonomy in GIScience. We have also provided an implementation of the framework in computer vision for learning the productions of a **BMOP**.

7.2 Limitations

Limitations of the proposed framework are:

- The proposed framework either accepts a motion pattern in entirety or rejects it. In real world, it is possible that a pattern may not occur exactly in the way we define it. It is necessary to formalise the nearness of an observed pattern to some already defined or learned pattern.
- The proposed framework can not learn negative examples.
- Another limitation of this work is the lack of serious evaluation in the sense that demonstrations have been presented using small volume of data. The framework has not been evaluated on large data sets.
- In the presented framework, time is represented at the level of a **BMOP**. This is a coarse grained representation that does not distinguish patterns in terms of temporal characteristics at the level of a state.
- The combined model of direction and orientation, introduced in chapter 3, may not be effective in processing video data as it is observed that direction is very sensitive to noise and accordingly, orientation labels change unpredictably.

7.3 Future Work

Following are some future directions of work:

- Representation and recognition of motion patterns of collectives has emerged as an important research area. In the case of a collective, it is necessary to represent the motion of the collective as a whole. Individual objects within the collective influence the motion of the collective. In **QDL**, we have **BMOP** and **MOP** to represent motion of multiple objects; but these types do not represent the collective motion of all these objects. We need to extend the syntax of **QDL** so that it can be used for representation and recognition of motion patterns among collectives.

- The volume of data in GIScience is large. Such large data sets are more conveniently stored in databases for faster access. In order make **QDL** work with databases, it can be extended as a host language where SQL statements can be embedded for data retrieval.

- A motion pattern, expressible in **QDL**, relies on the concept of a reference object. We represent the motion of objects with respect to a reference object. This limits representable patterns because a pattern may occur within a set of objects with some other object as the reference (i.e. not with respect to the object that we define as the reference). It is possible to redefine the semantics of **QDL** so that a each object is considered as the reference in turn. Such an extension will have to use *relation algebras* of binary qualitative relations for modelling movement parameters. The qualitative relations can be computed with respect to a single reference; but the relationship with respect to other reference objects can be computed using composition and converse of base relations. Semantics of **QDL** constructs need to be redefined.

- At present, **QDL** does not use any ontology about the objects in motion. Use of ontology will improve the recognition task. Moreover, ontologies can also help in handling error in input data.

- In parsing **QDL** constructs, error handling has not been incorporated. With error handling, a pattern may not be rejected outright if it does not match a learned or defined pattern. Instead, it may express closeness of the observed pattern to some defined pattern using probabilities or other measures.

- In the field of computer vision, it will be interesting to use the proposed framework for recognition of motion patterns involving a single object. Patterns like walk, run, dance, gestures etc. fall into this category of patterns. Since only one object is involved, movements of the different parts of the object need to be modelled. New qualitative formalism along with new **QDL** constructs may be necessary for representation and recognition of this type of patterns.