Advanced Model checking for the analysis of limbic system models

Summer internship proposal – Alice Miller

Student: Alex Trew

Project description:

Alex's level 4 project was an initial attempt to create a Promela specification of a model of a rat's limbic (emotional) system developed by Dr Bernd Porr (Biomedical Engineering). A limbic system model is a proposed network of areas in the brain that are responsible for a given emotional response. Different researchers often propose different models for the same system, but proving the correctness of one model over another is difficult and non-systematic. Bernd's model is based on a circuit diagram of the limbic system (www.berndporr.me.uk/limbic) and was previously implemented as a C++ simulation model (https://github.com/berndporr/limbic-system-simulator).

The approach used in Alex's level 4 project was to convert Porr's simulation model into Promela, in order to perform model checking using Spin. Advances made during Alex's project were satisfactory (initial attempts to perform the conversion automatically using existing tools proved too complicated, so a model was eventually constructed by hand). However, due to time constraints just as the project was getting interesting, it came to an end.

The project showed great potential for future work in the area of model checking proposed brain networks and Miller and Porr are in the initial stages of developing an EU project (together with a member of the Human Brain project and other EU partners) in this area. Having seen the results of Alex's project it has become clear that models should be based on circuit diagrams (that are meaningful to biologists, biomedical Engineers and Computing Scientists alike) rather than intermediate simulation models. It is also not clear whether Promela and Spin are the best tools to use in this context. Maybe Prism is better, or a different model checker ?

The proposal for this internship is for Alex Trew to use his experience during his project to help us with the following:

- Simplify the Promela model by modelling straight from the circuit diagram
- Investigate how this approach could be automated, via some intermediate language
- Develop Prism models
- Help with the writing of a conference/journal paper summarising results.

Expected outcomes:

- A clear understanding how model checking is beneficial to verify model of the brain and how this can be deployed
- Additional software for automatic circuit diagram -> model conversion and in general how brain circuits should be stored so that different parties can use them easily
- Paper, illustrating proof of concept
- Paper and ideas for EU proposal which requires the definition of work packages for different partners. The proposed work here will help us identify these different packages and the expertise needed.

Relevance to research: As I am hoping to be on sabbatical next academic year (2018-2019) I will have the bandwidth to explore this exciting new topic. The preliminary work has been done and the internship will at least provide the means to extend and write up the work done so far.

Suitability of student: As this project directly follows from Alex's project he is clearly the most suitable person to carry out this work.