Traffic Lights : Harnessing Distributed Control Intelligence

WebScience Stimulus Fund Project : Final Report – 11th August 2017

Project Overview

This project sought to draw parallels with the development of communities in virtual situations to improve the coordination between traffic light controlled junctions. A key issue to be explored was the extent to which potential conflicting goals of the individual and the community result in interaction, compromise, negotiation and dynamic alliances.

The initial mechanism for exploring this conflict and the focus of this stimulus funding was the development of a multi-operator simulation in which separate individuals could take control of the traffic lights at different (but closely located) road junctions, where the consequences of decisions made by one person impacted directly on one or more of the other participants. The participants would be competing both as a team against other groups of participants (equivalent to working together to achieve the best outcome for the social group as a whole) and also in competition with other group members (equivalent to trying to achieve the best personal outcome from the social community membership).

Alongside this underlying aim, a secondary objective was to collect data on how individuals who have little or no experience of traffic light control (beyond likely being a frequent user of the road traffic system as a whole) would choose to operate their traffic lights both individually and in co-operation (or possibly competition!) with others.

Project Achievements

Phases 1 and 2 of the project were related to the design and creation of the simulation that would form the basis for enabling, recording and exploring the control decisions and interactions between team members. A key design decision here was over the level of display detail required for the simulation to be realistic and engaging for participants, but not to distract from the key purpose of exploring the decisions and interactions. It was considered that the road layouts and infrastructure must be immediately recognisable, but that vehicles themselves should be restricted to identical cars only, portrayed as featureless cuboids to ensure that all were treated equally by participants. Two example road layout case studies were created.

The first example was a set of closely located urban crossroad junctions (Figure 1a) which were designed to represent the full level of complexity of vehicle turning movements and consequential traffic light combinations. In preliminary testing runs however it became apparent that this formed too great a challenge for novice participants and would require a substantial learning period in the formal trials.

The second example represented a roundabout interchange between two motorways. This created a set of four junctions on the roundabout (one at the top of each slip road coming from a motorway – Figure 1b) where the participant had only two options to choose from:

(a) a GREEN light to traffic leaving the motorway and a RED light to traffic circulating on the roundabout
(b) a RED light to traffic leaving the motorway and a GREEN light to traffic circulating on the roundabout

This simpler option appeared to be more quickly understood by people during the preliminary testing stage and provided a clearer indication to each participant that their decisions had consequences for the other people. It was therefore decided to use this example as the basis for the project trials

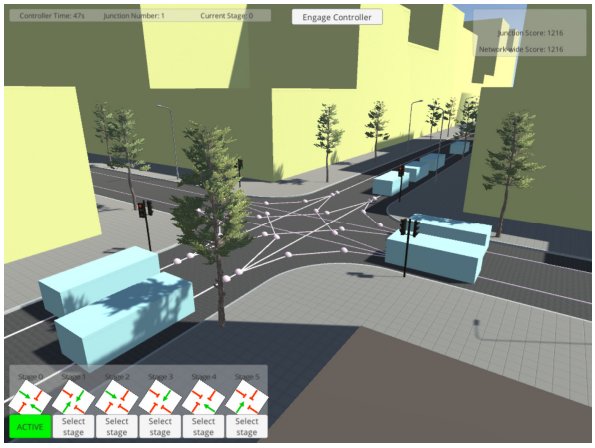

Figure 1a : Urban junctions simulation

Figure 1b : Roundabout junctions simulation

Phase 3 of the project was the full data collection trials which took place in late April 2017 (ethics ID 26193). The trials were storyboarded to set context and allow for participants to become familiar with the simulated environment and their roles, before being challenged to interact to achieve the best individual and/or group performance.

Nine teams (of four participants each) were assembled either as pre-existing groups (where the four people already knew each other) or assembled from individuals who wished to take part who had never met before.

For each team, basic demographic data was collected by questionnaire and the experiment and user interface explained. Participants were told only that their aim was to 'minimise the total level of annoyance for the road users'. Three simulation runs (of ten minutes each) were then carried out with additional questionnaires asking about the participants aims and levels of cognitive workload.

The four team members were seated at separate computers each displaying a close up view of the junction that the individual was controlling, in a circle equivalent to their relative position around the roundabout (Figure 2). A birds-eye (lower zoom) view of the whole roundabout was also displayed on a projected screen to promote interactions (and control strategy development discussions) between the team members. Audio recordings of the trials were made to capture discussions for subsequent analysis.

For the final ten minute simulation run participants were informed that the best performing individual (lowest individual junction annoyance) would win a £25 prize and that the best performing team would win an additional £300 (£75 each). It was observed that this provoked (as intended) a range of attitudes to the relative prizes both between and within groups.

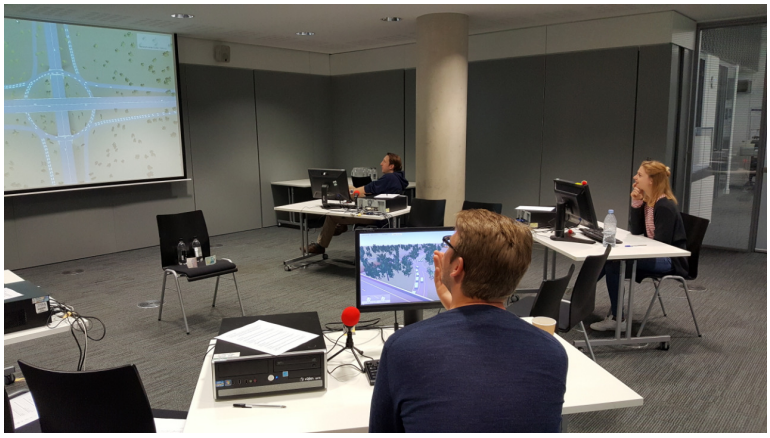
Figure 2 : Trial Configuration

Phase 4 of the project is concerned with the analysis of the collected data. In many ways we are now victims of our own success in relation to the amount that we have achieved within the project and the data will likely take some while for us to fully analyse and understand. One paper has already been accepted for a conference in September 2017 (on the experiences of running a multi-user trial in this way), preparation of the first journal paper has begun (on understanding the decisions taken by each participant) and there are plans for two more papers (related to the interaction elements and cognitive workload elements).

Financial Status

The contributions to staff time and commissioning cost for the simulation development were broadly in line with expectations from the initial proposal. A decision taken at the design phase to run the simulations on a local computer web rather than across the wider internet (see also future activities below) meant that expected data hosting costs were instead diverted to equipment costs (e.g. microphones for the audio recording). Expected digital asset costs were instead covered by CobaltOtter (the industrial partner who created the simulation package) and this budget was therefore diverted to form the prize pot for the trials.

In summary, the expected project budget was £12,500 from the Stimulus Fund and £8,000 contribution in kind from CobaltOtter and final expenditure was £12,093 from the Stimulus Fund (plus £8,000 from CobaltOtter).

Future Activities

Although it was originally intended that this Stimulus Funding would produce a single follow-on large scale research proposal, the interest that this project has generated as it progressed has led to a much wider range of project opportunities.

Marilyn-1
This parallel project has come about as a direct result of discussions with Southampton City Council about accessing the data streams necessary to transfer from a simulated road environment to a real life system. Part funded by the City Council and part funded by the WebSicience Institute this project is seeking to create the on-street monitoring and communication systems and cloud based data collection and analysis systems to provide real-time monitoring capability to road network managers.

Traffic Signal Control Algorithms
This represents the full scale research project (current estimated project cost (80% FEC) of circa £900,000) that was the initial aim of the Stimulus Funding. As the project has progressed this proposal topic has morphed towards the need to use the data streams from either real life systems (e.g. as in Marilyn-1) or simulated systems (as in this stimulus project) to develop and calibrate the next generation of control algorithms. The current draft of this proposal is enclosed with this report.

Collective Decision Making for Traffic Control
This represents the one aspect of the original proposal that we feel we have not been properly able to address within what we have achieved, the step of releasing a version of the simulation onto the wider Web to encourage greater participation. While too computationally complex to do directly, the approaches developed and learnt during this initial Stimulus Fund project have provided a clear understanding of how this could be achieved. It is intended that this project (proposal currently in early stages of development) would focus on enabling large numbers of people to participate simultaneously within a single simulation, with 'majority voting' style systems to control when traffic lights change colour rather than each person being assigned to an individual junction.

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