Food Security: An Intelligent Systems Approach

The aim of this project is to develop new work in the area of Food Security modelling using Intelligent Systems (ISs) techniques. As indicated below the food security area is very multi-disciplinary and hence to realise our objective the project needs input from a broad range of experts. Hence the team of colleagues who will provide valuable contributions including the PI and CIs indicated and additional CIs that form the team are: Engineering (Evor Hines (Intelligent Systems); Mark Leeson (System Modelling etc); Daciana Iliescu (Instrumentation)); Warwick HRI (Rosemary Collier; food security expertise, datasets, link to DEFRA, etc); Sociology (Liz Dowler; access to food production and other forms of data, extensive contacts and knowledge in the area – e.g. is on a government committee on food security); Politics and International Studies (Wyn Grant; many years of experience and interactions with decision makers, etc); Centre for Applied Linguistics (Keith Richards; expertise in the way in which experts communicate and how to optimise effectiveness); and WBS (Yasmin Merali; input on complexity, economics etc).

The concept of Food Security presents different images to different people. It is impacted by a very broad range of perceptions and circumstances as perceived for example by 1) those who are relatively poor individuals who may not have hardly anything to eat on a daily basis; 2) at the other extreme there are those who have plenty to eat but require what they eat to be of a very high quality to fit circumstances such social status; 3) those who may be ill and hence need high quality in the sense of nutrition; and so on. The production of food is controlled on various levels ranging from global to national/local and the variations in between. From a UK perspective those with the responsibility to ensure that there is a sufficient quantity, quality etc to meet the various needs of all members of society at the 'right' price etc are finding it ever more difficult to realise their objectives. Some of the key players being the government, food suppliers, the growers, and so on. In the context of modelling such a system in order to produce tools to support decisions makers in a holistic sense to meet the different needs/objectives of decision makers one is faced with two broad types of data/information which may be available: 1) at one extreme there is 'hard data'; this being quantitative in a statistical sense such as the number of broccoli that are grown by a particular farmer annually; and 2) at the other extreme decision makers may at the upper levels expresses their 'policies' in more subjective terms such as 'we need to increase production a bit'; the latter form being traditionally difficult to quantify and is rarely accepted to be of sufficient 'accuracy' to be used with much confidence to inform the development of models. As well as those two forms of data there are issues to do with uncertainty in the data and for example some data may be missing. In addition over recent times the issue pertaining to the growing world population and climate change have added to the dimension complexity, etc of the problem. The model is required to be more or less a quantitative so as to best suit the particular needs of the different decision makers and on which they can rely. In the case of food security reliable information is required to for example to ensure that there is the correct quantity and quality of food to meet the needs of the UK population, accounting for all the factors that may impact adversely on say UK food production. In one scenario we may consider UK food production in isolation (as far as that is possible) but in reality for such models to be realistic they need to incorporate global food data/information. Traditional techniques can not deal effectively with the issues. Hence the need for this work.

As far as we are aware there is no system which is able to do what we are proposing to do effectively. Given the scale of the problem in this project we plan to collate input from the experts and formulate the concept of a 'stage 1 system' which will model for example a realistic local scenario of appropriate scale to be informative in terms of the subsequent development of a 'stage 2 system' in subsequent work. We will make use of data/information which is already available via the team or can be accessed via contacts and so on. The system will be developed using Intelligent Systems techniques. Some of the particular possible benefits ISs have to offer are: 1) Fuzzy Logic (FL) type approach will be used as the key mechanism to deal with the soft/hard data/information processing due to for example it's possibilistic rather than probabilistic roots; 2) Artificial Neural Network (ANN) principles will then be incorporated such that the system is able to learn (supervised or unsupervised) from the data available in order to inform the model; and 3) Genetic/Evolutionary Algorithms (G/AEs) are able to determine optimized solutions to single and multi-objective optimization problems; hence they may be used for example to help the model self optimise. Other ISs techniques which may have a part to play include 1) hybrid ISs techniques which combine the relative merits of the techniques which

are combined, an example being Neuro-Fuzzy Systems (NFSs) which are able to learn from data and work in a possibilistic manner; 2) Genetic Programming which is an extension of GAs which is able to automatically create programs, as determined by the optimization criteria, which can solve the sort of problems a GA may be applied to; and 3) Swam Intelligence (SI) which is an alternative form of optimization strategy.

The project is a preliminary test, to see how the system we to produce performs in dealing with the hard/soft data/information from a possible multitude of disparate sources to perform effectively as a food security decision support system. Having proved the principle using a relatively small scale 'stage 1 system' future collaborative work will be put in place to take the work to the next stage.

The intended outputs are:

- feasibility report on the potential for developing novel Food Security modelling using Intelligent Systems (ISs) techniques, due at the end of project for internal circulation
- inter-departmental presentation for dissemination of results in the associated Departments and elsewhere as far as possible
- Produce a poster and several publications
- We will present the results to key stakeholders via which to seek further funding, for example from DEFRA, BBSRC, etc
- We will also explore funding opportunities to explore other possible areas to which the 'stage 1 system' may be applied in in collaboration with other staff at WHRI, and elsewhere
- we will look for opputinies via the various schemes avaiable at Warwick and elsewhere to secure researches to continue the work
- Collaboration between Enginerring, Warwick HRI, Sociology, Politics and International Studies, Centre for Applied Linguistics, and WBS.

Potential for a PhD project: It is possible to extend the project in many directions in order to meet the needs of quite a number of interested PhD students.