A Dynamic Model for Identifying Enemy Collective Behaviour

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Aims

- The aims of this research are:
  - to look at ways of identifying groups and activity between groups and to infer intentions by examining characteristic group behaviours and indicators of intention;
  - implement prototype implementation of developed algorithms for verification and validation testing.
- The benefit of this work is that developed algorithms:
  - will drive the C2 Deliberate Planner;
  - produce more dynamic responses to enemy action;
  - will lead onto the possibility of representing agile mission groups and effects based modelling in a Comprehensive Approach framework.

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Introduction

- Need
  - a more dynamic approach to C2 decision-making;
  - remove the need for fixed rules and pre-determined C2 decision options/paths;
  - represent agile mission groups and Comprehensive Approach.
- Approach
  - develop ideas for cues and an approach to implementation;
  - method should be dynamic – have a ‘learning’ capability;
  - portable to enhance other C2 decision models (e.g. the Deliberate Planner (DP)).

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Background: academic link

- Data and Information Fusion (DIF) Defence Technology Centre (DTC)
  - formal arrangement between industry and academic experts;
  - cutting edge research to facilitate the early exploitation of novel and enabling technologies.
- Imperial College (IC) research
  - IC have researched and developed modelling system that uses information available about teams/coalitions to design tactical decision-making tools for simulation[1];
- IC and Dstl research
  - IC has built upon this framework by investigating and partially solved the 'inverse problem' proposed by Dstl to discover collaborative behaviour.

[1] MIMEX – 6.8 strand:- 'Future Data Fusion Systems: Design and Demonstration'

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Background: the Deliberate Planner

- The C2 DP process is based on an analytical decision-making process – *rational choice decision-making*:
  - selection of a Course of Action (CoA) and development of plan to execute that CoA;
  - issuance of directives to carry out that plan;
  - supervision of the planned action.
- This paper presents a method to improve the process:
  - remove the need for prior knowledge of CoA set – no need for ‘an explicit generation’ of the CoA;
  - modelling process aimed at ‘discovering’ those indicators that could lead to the prediction of a set of CoA of the enemy.

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Modelling approach

- Multi-agent model – neural network framework:
  - Navigation module – ‘danger’ avoidance;
  - Grouping module – drives the collaborative behaviour;
  - Imitation module – inexperienced agents will aim to mimic the behaviour of the successful agents of a group.
  - Co-ordinator module: combines these decisions to form an ‘overall’ decision.
- No pre-conceived knowledge – ‘learn’ from zero.
- Initial indicators include:
  - those based on spatial (e.g. separation distance);
  - those based on behaviour (e.g. velocity).

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Results

- All results presented follow the UNCLASSIFIED scenario:
  - Blue team has to go to the destination (represented by the shaded rectangle) while avoiding the Red team;
  - Red team has to intercept and destroy the Blue team while avoiding the Green team;
  - Green team has to support the Blue team by trying to intercept and destroy the Red team.
- Terrain obstacles represented by (green) ‘blobs’.

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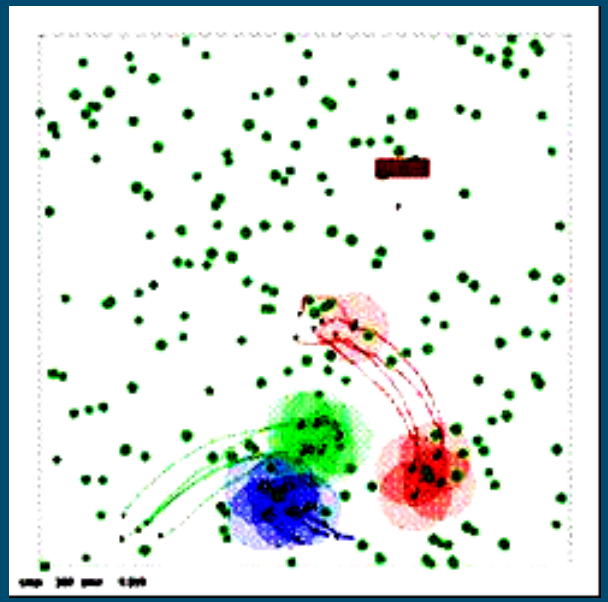
Results – spatial representation



Blue team aims for destination (shaded rectangle). Red team tries to attack Blue team; Green team intercepts Red team.

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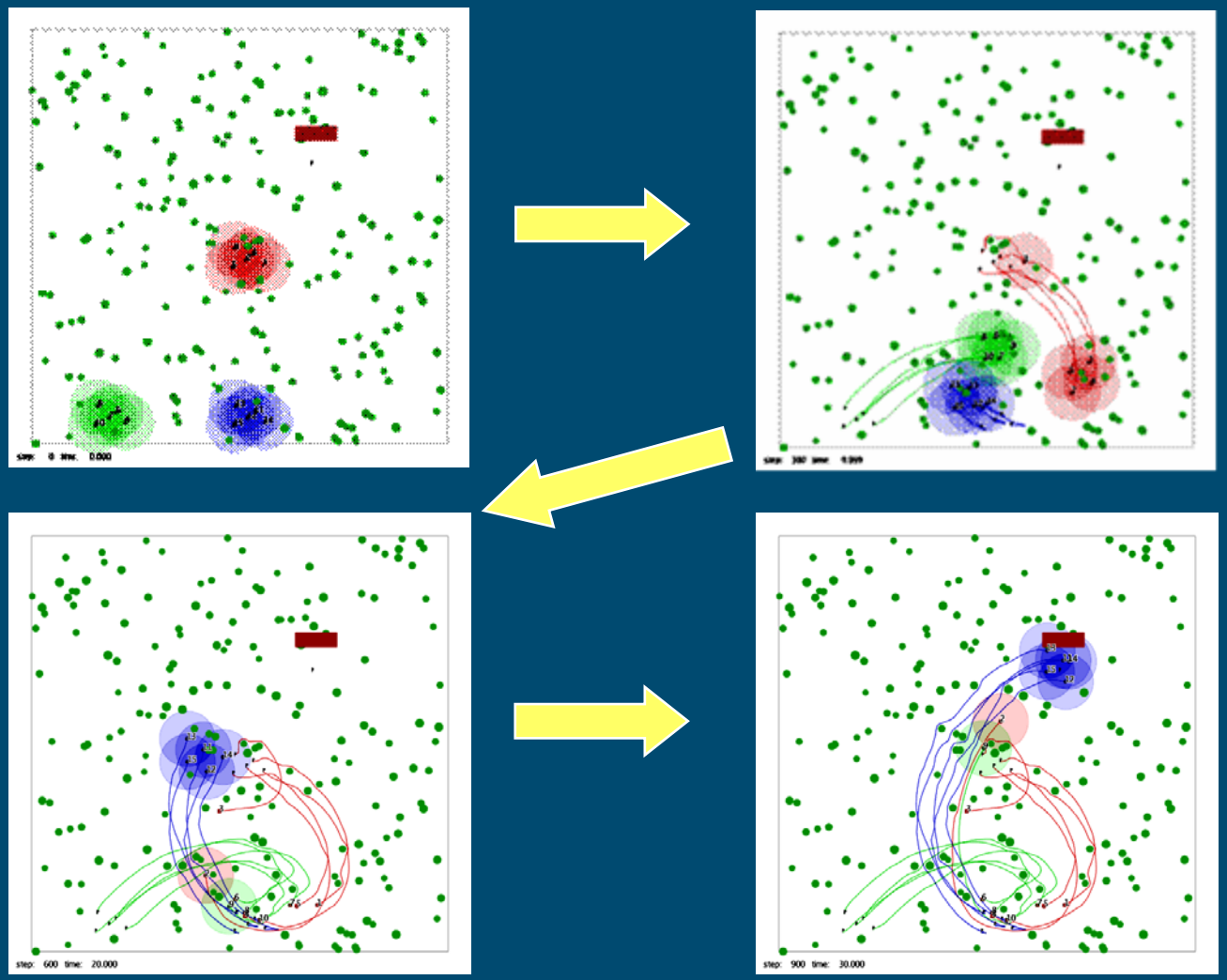
Results – temporal illustration



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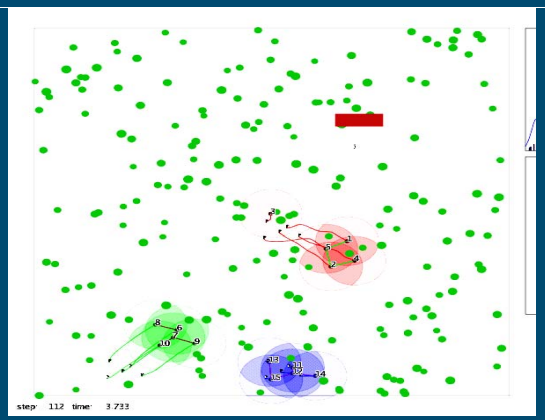
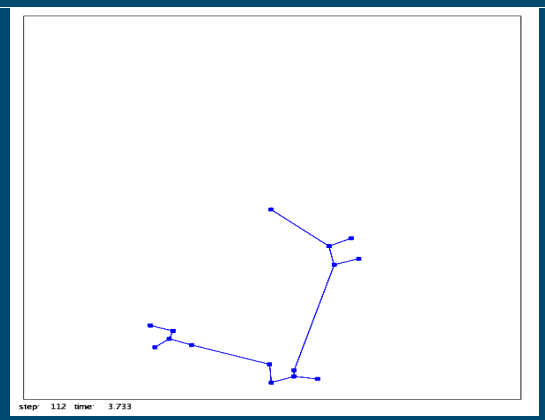
Results – discriminators

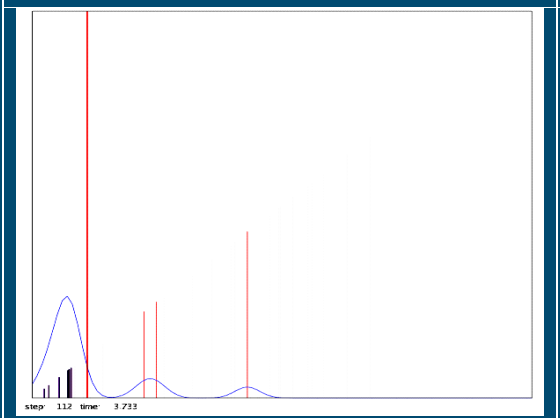
- Both spatial and behaviour indicators of collaboration can be separately determined using a minimum spanning tree (MST)



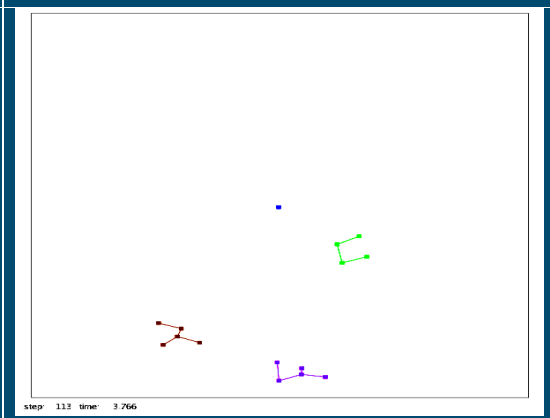
a) Simulation screenshot, 15 agents.



b) MST based on spatial metrics.



c) Histogram and density estimation of MST edges.



d) Partial MST forest after removal of edges above the cut-off limit.

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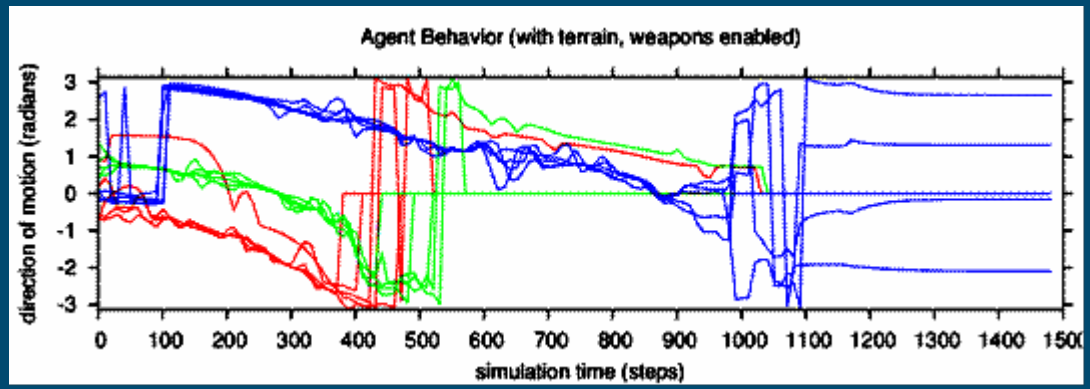
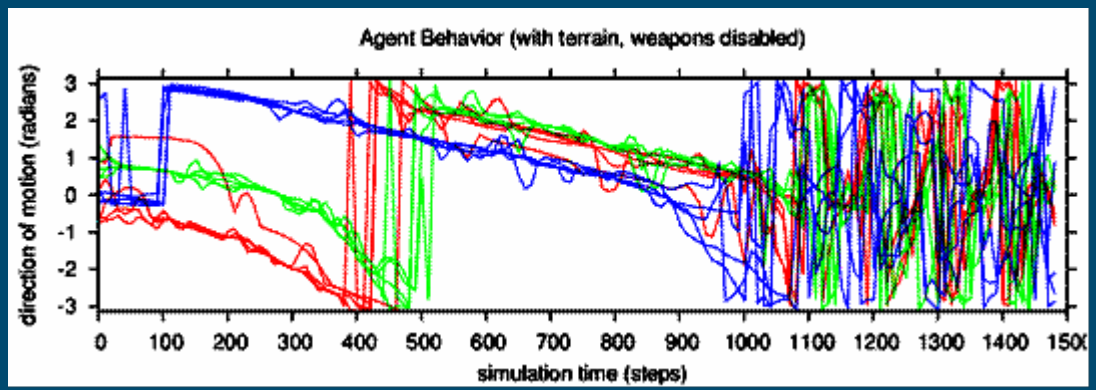
Results – behaviour example

- Contrasting behaviour in the enemy with and without weapons
  - weapons have stabilizing effect





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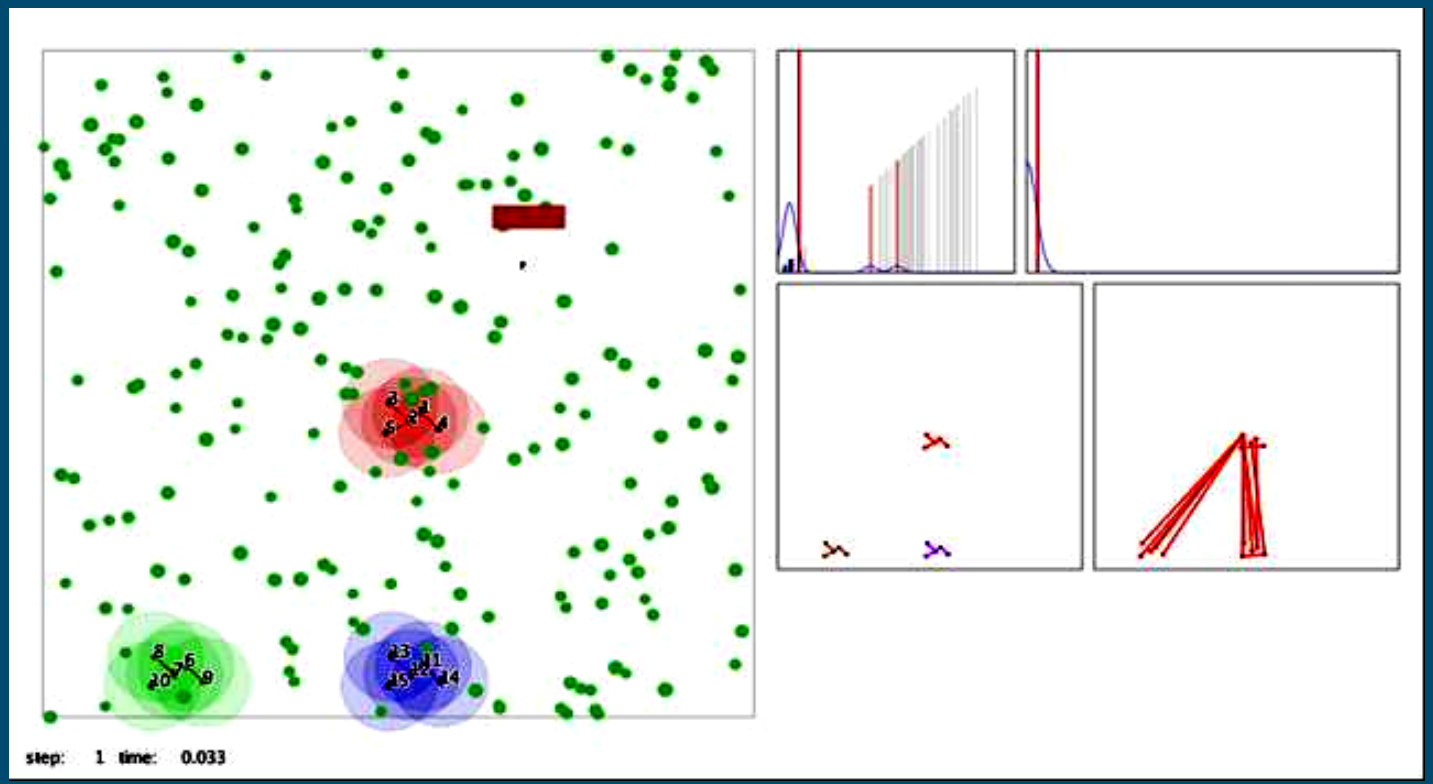
Results – spatial and behavioural

- Example of good spatial but poor behaviour clustering



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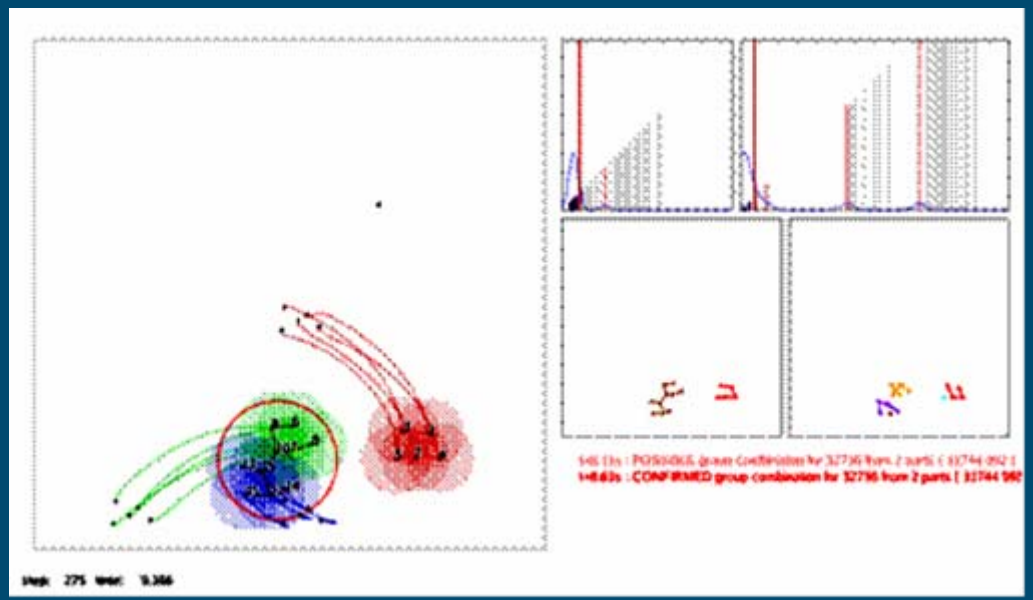
Results – spatial and behavioural

- Example of good behaviour but poor spatial clustering



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Summary and Conclusions

- Dynamic technique – neural network approach
  - spatial and behavioural classifiers;
  - extendable to include other classifiers.
- Avoids rule-bases or large volume input data
  - capable of ‘discovering behaviour in the enemy’.
- Will be used to improve the C2 Deliberate Planner capability
  - more accurate prediction of force size and structure.
- Approach suited to looking at agile mission groups in an Comprehensive Approach environment
  - WISE gaming output to be used for V&V purpose.

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