

Implementing the Optimisation Algorithm

Vehicle Routing Problems belong to the group of NP-complete programs that are known to be hard to solve. In general, the computation time for solving a VRP increases exponentially with the overall number of customers. Even execution times for heuristics and meta-heuristics suffer from this effect. For optimisation problems of a certain size only the development and implementation of highly parallel algorithms may achieve reasonable execution times.

Optimisation algorithms are usually implemented in Fortran or C due to the high-performance compilers that are available for these languages. Next to efficiency, additional criteria such as programming convenience, adoption of technology and availability of tools could also justify the use of C++ as a programming language.

Real World VRP Example

The use of GIS for optimisation in transportation planning described above was applied in a project dealing with the development of a decision support system for transportation of blood donations in Austria. The underlying optimisation problem originates from the blood collection process of the Austrian

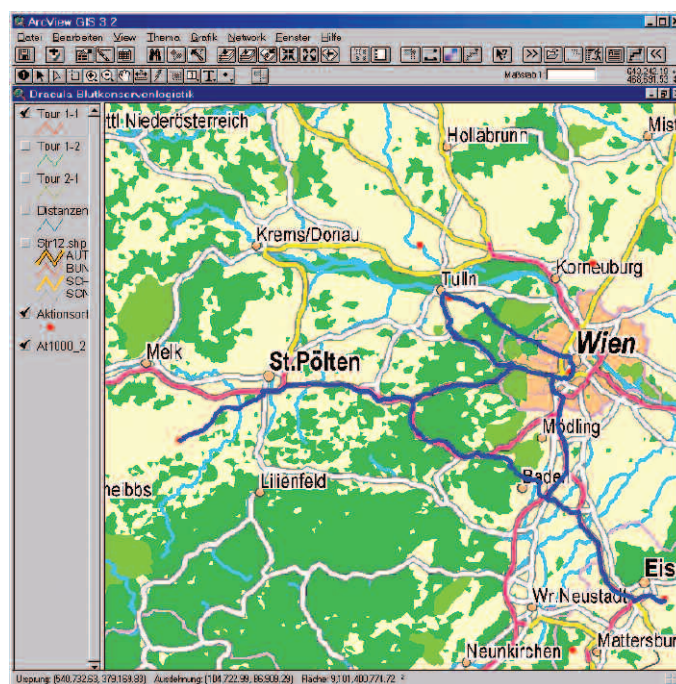


Figure 2: User interface of a decision support system for transportation planning.

Red Cross blood program, where processing requirements state that all blood must be processed in one centrally located blood bank within four hours of donation. This restriction causes a significant amount of vehicle movement, which could be reduced with problem-tailored optimisation algorithms by more than 25%, as measured in total driving time. Figure 2 depicts the user

interface of the transportation-planning tool developed in this project.

Please contact:

Günter Kiechle
Salzburg Research
Forschungsgesellschaft, Austria
Tel: +43 662 2288 421
E-mail:
guenter.kiechle@salzburgresearch.at

GIS Technology for Maritime Traffic Systems

by Cyril Ray, Thomas Devogele, Valérie Noyon, Mathieu Petit, Sebastien Fournier and Christophe Claramunt

At the Naval Academy Research Institute in France, collaborative research in the fields of Geographical Information Systems (GIS) and maritime transportation is producing data models and computing architectures that favour the development of traffic monitoring and analysis for decision-aid systems.

Safety and security are constant concerns in maritime navigation, not least because of the constant increase in maritime traffic and reduction of crews on decks. This has favoured the development of automated monitoring systems such as the Automatic Identification System (AIS) and the Electronic Chart Display and Information System (ECDIS). However, officers on the watch and monitoring authorities require additional and advanced decision-aid solutions that will take advantage of these communication and cartographical systems.

The development of geolocalisation, information and telecommunication technology offers higher traffic data availability, but presents new challenges for the integration, analysis and delivery of maritime traffic data. Hence there is a great need for integrated traffic systems that are able to cope with all these technological domains. The development of a real-time integrated maritime platform implies a reconsideration of storage, modelling, manipulation, analysis and visualisation functions, since current models have not been designed to handle such dynamic phenomena.

One of the most promising solutions to this problem is the integration of Geographical Information Systems (GIS) with maritime navigation systems. Our approach relies on a monitoring project, the purpose of which is to integrate heterogeneous positional data from three sources: an Automatic Identification System (AIS), public traffic data available from the Internet, and a real-time monitoring system developed for sailing races. These systems generate geolocalisation frames from different types (eg AIS frames) and from different ad-hoc networks (eg VHF for AIS, WiMAX for

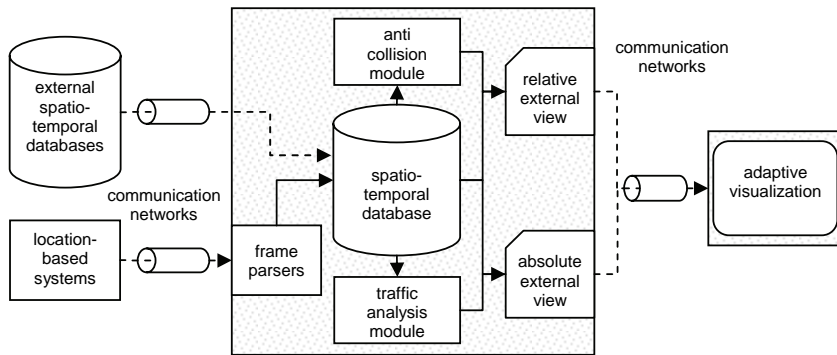


Figure 1: Integrated GIS.

sailing races). Coupled with external databases, this constitutes the input for an internal spatio-temporal database that manages historic and real-time data. These data include maritime trajectories, vessel characteristics and environmental data.

The framework developed so far integrates several modules. One of these is an anti-collision function that monitors the risk of running aground and evasive ship behaviour. This module also integrates simulation capabilities in order to control and predict the evolution of ship behaviour and trajectories. These simulations are based on a multi-agent system and micro-simulation capabilities, where ships are modelled as autonomous agents acting in their environment according to maritime rules. The module is designed for maritime authorities and for educational and training purposes. Moreover, the traffic analysis module integrates intelligent inference mechanisms that can use data mining to derive traffic patterns. The objective is to observe and understand maritime traffic at different levels of granularity.

Two complementary external views are of interest in maritime traffic monitoring. One is the conventional absolute view of spatial trajectories. The other combines the relative position and velocity of mobile ships with respect to an observer. This relative external view helps users to perceive traffic evolution according to their point of view and aids their perception of the underlying processes that emerge from the ships' behaviour.

Current research into users' interaction with the system is focusing on the concept of adaptive GIS. This can be

defined as a generic and context-aware GIS that automatically adapts according to its context. The context is defined by (i) the properties and location of the geographical data being manipulated (eg maritime traffic data); (ii) the underlying categories that reflect different user profiles (eg port authorities); and (iii) the characteristics of the computing system, including Web and wireless techniques. In all, the use of adaptive GIS as a decision-aid system appears to be a useful approach for maritime transportation systems.

The framework developed so far represents a preliminary step towards the development of integrated GIS and maritime information systems. A number of research challenges remain. One is the development of cross-domain protocols and exchange standards for the trans-

mission and interoperability of traffic data; another is the integration of different geographical information sources that are combined, adapted and shared in real time between different levels of users acting in the maritime environment. Conventional statistical, geographical data analysis and visualisation methods should also be adapted to the specific nature of maritime traffic information. Traffic data and applications are usually physically allocated in different geographical locations and are computationally expensive in terms of the data volumes generated. Hence, there is also a need at the implementation level for the development of a GIS-based distributed computing environment, and computational and processing capabilities. Overall, the development of GIS for maritime information systems should improve the management and planning of maritime navigation, thus favouring the search for a safer sea.

Links:

GIS research group of Naval academy:
<http://www.ecole-navale.fr/fr/irenav/groupe/sig/sig-en/>

Please contact:

Cyril Ray
 Naval Academy Research Institute,
 France
 Tel: +33 298233611
 E-mail: ray@ecole-navale.fr

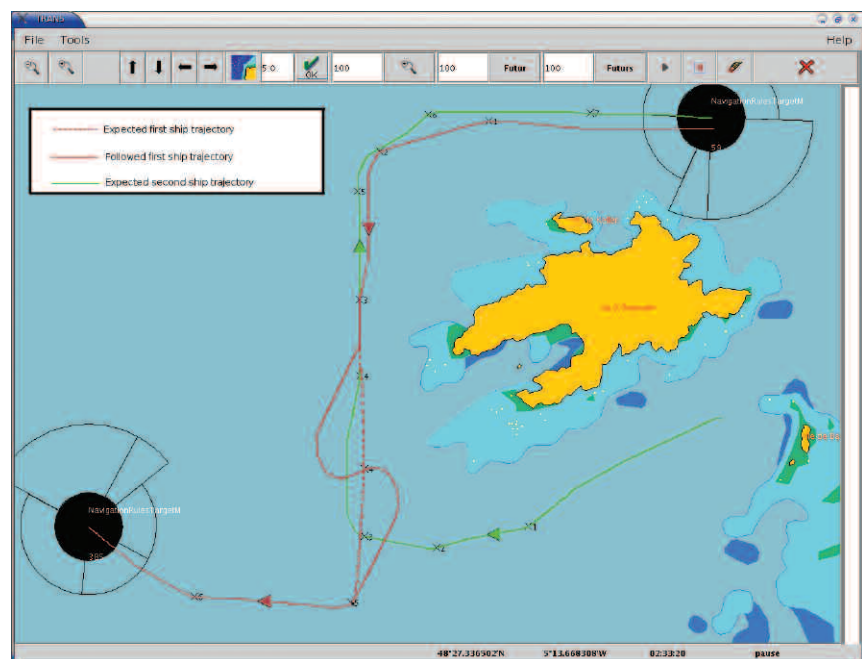


Figure 2: Illustration of anti-collision module.