A GIS-based FOSS decision support system for the management of SAR operations in mountain areas

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A GIS-based FOSS DSS for the management of SAR operations in mountain areas

what happens when a person gets lost?

- fatigue
- cold
- confusion
- fear
- darkness
- forest
- river
- experience
- missing person

DECISIONS

- information
  - personal experience
  - archive
  - cognitive biases
  - rescue team
development of an integrated system for the management of search and rescue (SAR) operations

past operations archive

GIS model for the assistance to the SAR campaigns

real time rescue units tracking and coordination

THESE THREE ISSUES ARE TIGHTLY CONNECTED AND MUST BE MANAGED TOGETHER
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Development of an integrated system for the management of search and rescue (SAR) operations

MODELS:
- **deterministic**: defines the maximum search area as a function of time
- **stochastic**: indicates areas with more probability of containing the missing person

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development of an integrated system for the management of search and rescue (SAR) operations

Components:

- WebGIS, provides an interface to the final user, both for giving model input and for browsing model's output; triggers model application
- spatial DBMS, provides an unique repository for data collecting and retrieving
- GIS runs the search model
- php connects the components above
GIS model for maximum search area definition

- behavior
  - subjective
  - time function

- physiology
  - subjective
  - time function

- environment
  - objective
  - time function

- archive
  - objective

- weather
- terrain morphology

- GIS

- INCREASE THE AMOUNT OF INFORMATION
- INCREASE THE CAPABILITY TO USE INFORMATION
- REDUCE SUBJECTIVE DECISIONS
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**GIS based model**

**physiology**

sex
age
training level

fatigue [time]

**environment**

terrain slope
terrain height
terrain roughness
vegetation density
rivers
streets network

visibility [time]

to develop a map of max search area

at a given time the isochronous line gives the maximum extent of the search area (i.e. the maximum area a person can reach)
GIS based model

to develop a map of maximum search area

the maximum possible speed of the missing person is evaluated by comparing the energy required to move on the terrain and the available energy to the missing person. This gives the maximum area a person can reach as a function of time.

physiology – available energy

available energy is calculated as a function of the missing person features and of time

environment – energy requirement (cost)

energy requirement (cost) to move on the terrain as a function of terrain features, obstacles and roads network
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**GIS based model − cost**

Energy requirement (cost) to move on the terrain as a function of terrain features can be evaluated once for all to create a **cost map**

\[
\text{req. energy} = \text{slope} \cdot \text{height} \cdot \text{veg} \cdot \text{ter}
\]

<table>
<thead>
<tr>
<th>Level</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>0 smooth</td>
<td>1.00</td>
</tr>
<tr>
<td>1 loc. rough</td>
<td>0.95</td>
</tr>
<tr>
<td>2 part. rough</td>
<td>0.90</td>
</tr>
<tr>
<td>3 tot. rough</td>
<td>0.85</td>
</tr>
</tbody>
</table>
GIS based model

available energy from physiological parameters of the missing person must be evaluated each time

\[ \text{avail. energy} = \text{sex} \cdot \text{fatigue} \cdot \text{train.} \cdot \text{age} \cdot \text{vis.} \]

<table>
<thead>
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<tbody>
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<tr>
<td>1 low</td>
<td>1.00</td>
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<tr>
<td>2 mean</td>
<td>1.40</td>
</tr>
<tr>
<td>3 high</td>
<td>2.00</td>
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</table>

<table>
<thead>
<tr>
<th>sex</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>male</td>
<td>1.00</td>
</tr>
<tr>
<td>female</td>
<td>0.92</td>
</tr>
</tbody>
</table>
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GIS based model

training level

25 years high train level  45 years low train level
Obstacles and preferred paths

The model takes into account obstacles, preferential paths and fords.

- Hydrographic network, non crossable rivers
- Roads networks, roads and paths
- Bridge
Model calibration and test

The model has been calibrated and tested with a GPS campaign.

A group of people with different ages, training levels, etc. has been tracked with GPS:

- a dataset has been used to calibrate the model's parameters
- a dataset has been used to validate the results

Male, 24 yro, medium training level

Time steps of 10 min
Error analysis

The error has been propagated analytically to evaluate the relevance of each parameter and its uncertainty on the precision of the localization of areas' boundaries.

RMS:
805 m after 30 min
1600 m after 1 h

the “training level” parameter plays the most relevant role.
Error analysis

If the uncertainty on the training level is removed, the accuracy increases remarkably.

RMS:
150 m after 30 min
305 m after 1 h
460 m after 1.5 h
two GRASS modules have been written:

- one to prepare a map of the energy requirement (cost) to move on the terrain as a function of terrain features
- one to evaluate the maximum search area as a function of time, using the “cost” map, the coordinates of the point of disappearance and the physiological parameters of the missing person

The first module must be used only once for each area and the “cost” map can be evaluated in advance and stored for later use.

The modules are being tested and will be made available when ready.
coordinates

The coordinates of the point of disappearance can be given by clicking on a map or by inserting the coordinates directly (e.g. as read from a GPS).

physiological parameters

These parameters are inserted using a web form, consistency checks are applied before inserting a new record to the DB.
Database

Two schemas are in the PostgreSQL DBMS:

- **param**, for all the tables containing the relationships between parameters (age, sex, training, etc.) and coefficients
- **data**, collecting missing persons' data and corresponding parameters (evaluated using the tables in the param schema)

Tables in the first schema are modified only when the model is modified, e.g. when new coefficients' estimates are available.

Tables in the second schema are modified each time a new operation start: a new record is added to each table.
What is ready?

By now:

- the GIS deterministic model is working and the corresponding GRASS modules are ready, tests have been carried out successfully but more tests are due
- the database structure is ready and it is being feed with data
- the web interface works, passing data to the DBMS
What is being done?

By now:

- the GRASS automatic execution via php is being implemented
- the database structure is being improved to better separate persistent data (coefficients) from missing persons' data
- the webGIS interface is being improved by adding cartography, adding new search tools such as place search by name and modifying the mouse coordinate capture widget
- an automatic reporting tool is being developed
- independent tests for the model are being carried out for different alpine region
What is still to do?

Still to be done:

- the inclusion of behavioral models and psychological parameters in the deterministic model
- the GIS stochastic model
- more extensive model tests
- real life applications testing the overall feasibility of the system
- real time units tracking (available from proprietary software vendors)

Collaborations with other research groups are being defined to address these issues.