Towards an Integrated Concept for Geographical Information Systems in Disaster Management

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Content

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- Distributed image database for content oriented searches
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Challenges for Information Technology

- Decisions in disaster management:
  - need to be based on a complete picture of a complex situation
  - have to be taken fast
- Information systems for decision making need to:
  - combine uncertain information from multiple source
  - process very large amounts of data in short time
  - present all relevant information in a clear and unambiguous way to decision makers
- *Information Systems in disaster management take current information technologies to their limits!*

Some Information Technology Challenges

Efficient Access to Very Large Databases

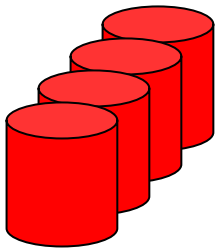
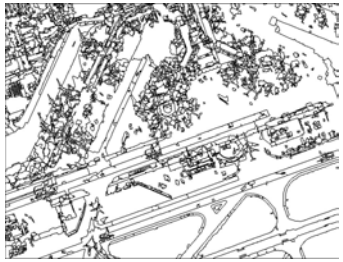
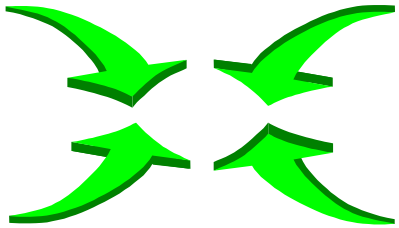


Image Interpretation



Connecting Systems and Services



Efficient Access - Sample Search Conditions

- Find satellite images with acquisition dates between 01.10.2004 and 31.10.2004 . . .
- . . . and cloud cover less than 10%
- . . . overlapping a rectangular geographical region
- Find a pair of satellite images
  - image one before 1.10.2004
  - image two after 01.10.2004
  - with minimal difference in total brightness

Efficient Support of Search Conditions

- *Index structures support efficient navigation to result sets*
- Lower and/or upper bound for a single attribute
  - support by conventional index structures
  - search time grows logarithmic with number n of entries: O(log(n))
- Lower and/or upper bound for several attributes
  - support by "non-replicating multidimensional" index structures
  - search time $O(n^{(d-1)/d})$ with *n* entries and *d* attributes
- Values in search condition need to be computed from entries
  - no support by index structures possible
  - search time grows at least linear with number n of entries: O(n)

Integration Challenges

- Query concept of a distributed system needs to consider limitations of database indexing technology
- Image interpretation needs to be harmonized with the query concept, if queries may refer to derived information.
- . . .

Integration Challenges

- Information Systems in disaster management take current information technologies to their limits!
- An integrated concept needs to be aware of these limitations:
  - A component may not impose requirements on another component which are difficult or impossible to achieve
  - Components should complement capabilities of other components
- *Thesis : Significant progress requires harmonisation of methods from different fields for specific application domains*

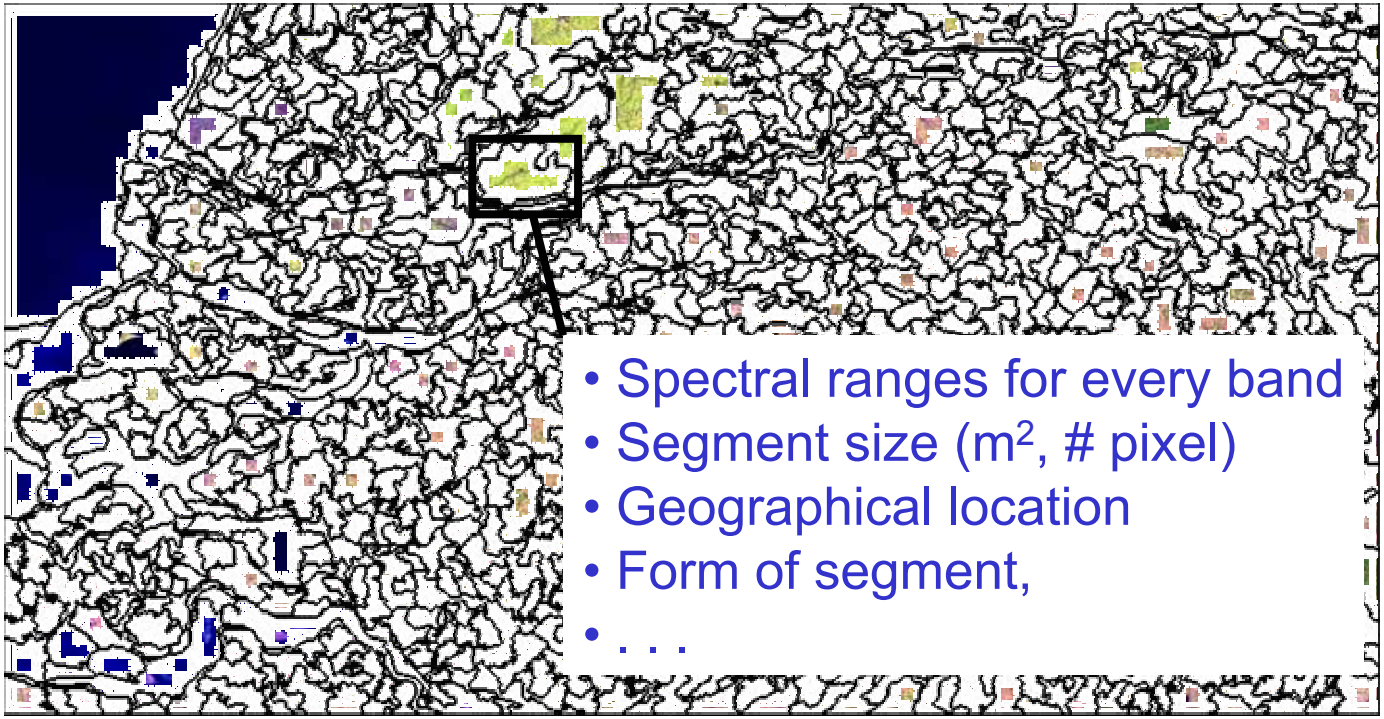
Content Based Search – Requirements

- Find images containing certain objects as for example:
  - damaged buildings in a given region
  - military vehicles close to refugee camps
  - dry forest areas above 10 m^2
  - . . .
- Images are stored in different archives
- Catalogues and archives are not aware of application specific queries

Content Based Search – Options

1. Apply interpretation algorithms to all images without database support
   - flexible
   - slow
   - in general very difficult
2. Store selected objects from images in database
   - inflexible, limited to selected objects
   - fast
3. Store generic parameters database
   - more flexible than 2 – less flexible than 1
   - fast, if database limitations are considered

Content Based Search – Pre-Processing



Original Image → Segmentation → Parameters

Content Based Search – Query Generation

- Initial query - Find images containing forest areas above 10 km^2.
- Derive conditions for segment parameters:
  - spectral range of forest needs to include spectral range of segment
  - size of segment greater than 10 km^2
- Retrieve all images satisfying conditions
- Apply image interpretation method to found images

Summary

- Proposed concept
  - works well if only few images are returned for image interpretation
  - does not work if almost every image is returned for image interpretation
- Image interpretation and database indexing methods complement each other in this concept
- Customised Web Services support a distributed information system
- *Remember: Information Systems in disaster management take current information technologies to their limits!*