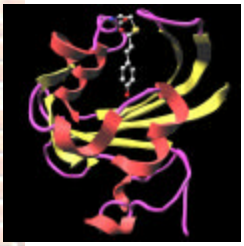
Interactive Virtual Environments
Mark Overmars



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10 december

CWI, Amsterdam

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People Involved

- **Utrecht University**
  - Mark Overmars (project leader)
  - Frank van der Stappen
  - Rene van Oostrum
  - Dennis Nieuwenhuisen (PhD)
  - Rob van Gulik (PhD)
- **TU Delft**
  - Frits Post
  - Erik Jansen
  - Michal Koutek
  - Gerwin de Haan (PhD)
- **CWI**
  - Robert van Liere
  - Postdoc (may 2005)

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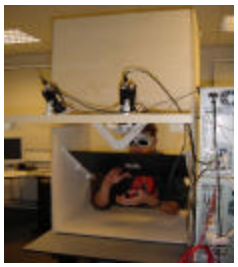
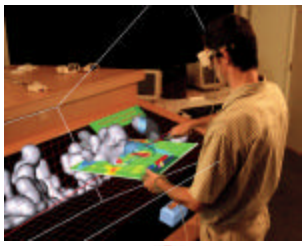
Research Questions

- **Effective special devices**
  - Personal Space Station
    - Two handed input
    - Shared environment
  - Virtual Workbench
    - Interaction concepts
    - Tools for selection and manipulation
    - Visual and physical feedback





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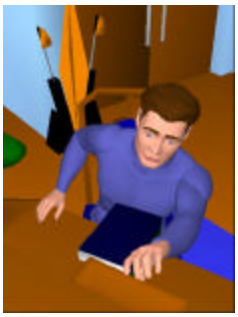
Research Questions

- **High-level interaction techniques**
  - Navigation
    - Assisting navigation through the environment
    - Automatic (camera) motion
  - Manipulation
    - Simulate manipulation
    - Plan tasks like grasping



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Assisted Navigation

- **Current situation**
  - Users directly steer their avatar (or the camera) through the environment with joystick or keyboard
- **Problems**
  - Is difficult for untrained users
  - Takes a lot of mental energy
  - Leads to visually poor images
- **Solution**
  - Partially automate the process
  - Let user specify more global goals

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The View

- **First person view**
  - User directly steers the camera
- **Third person view**
  - User steers an avatar
  - Corresponding camera motion is computed
    - Difficult problem in itself

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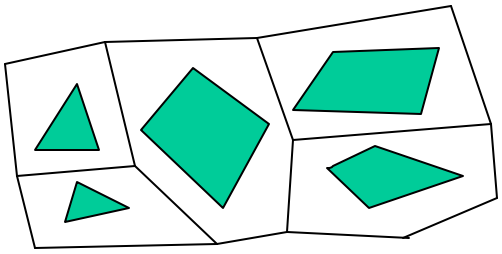
Navigation Network

- **A virtual world induces a navigation network**
- **Graph describing the homotopically different paths**



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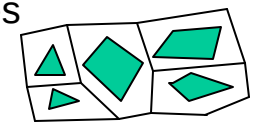
Navigation Network

- **The nodes relate to navigational decision that must be made**
  - By the user or by the system
- **Edges can be used to guide the motion**
  - No need to follow them exactly
  - Requires additional properties



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Creating a Network

- **By the designer of the world**
  - Is a lot of work
  - Is restricted to fixed worlds
- **Automatic during preprocessing**
  - Voronoi Diagrams
  - Probabilistic Roadmap Planner
- **On the fly**
  - Better adapt to changes

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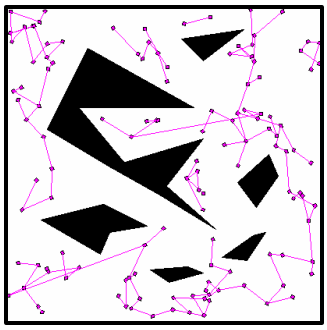
Probabilistic Roadmap Planner

- **Construction:**
  - Pick a random position c
  - If free, add it as a node to the graph
  - Find some nearby nodes $c_1 \ldots c_n$
  - For each i
    - When a straight line motion from c to c_i is collision free, add the edge to the roadmap
  - Repeat



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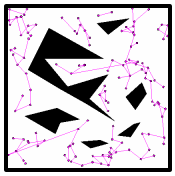
Problems

- **Covers space but not the homotopy classes**
  - Add cycles
  - Add an edge when the edge is much shorter than the current path through the graph
  - Can be done efficiently, avoiding expensive graph search



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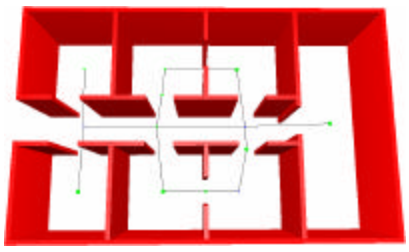
Problems

- **Has too many nodes**
  - Only add “useful” nodes
  - Push nodes to places where they cover large portions of the free space



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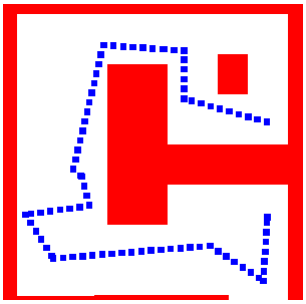
Problems

- **Can lie close to objects**
  - Push nodes and edges away from the objects



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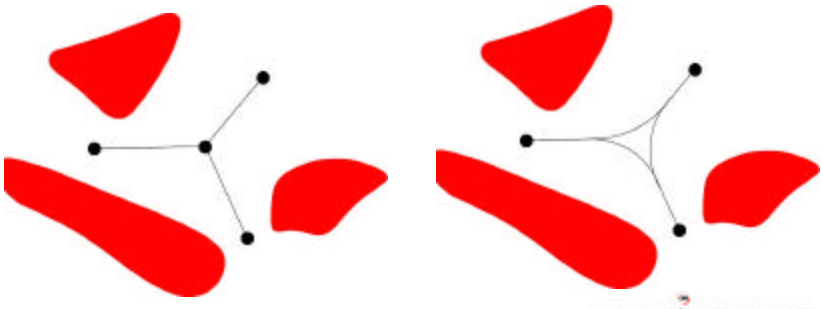
Problems

- **Has C1 discontinuities at the nodes**
  - Replace nodes by circle arcs



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Result

- Smooth roadmap, resulting in smooth paths

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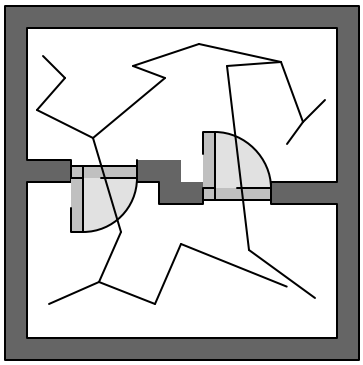
Changing environments

- Dealing with known changes, like doors



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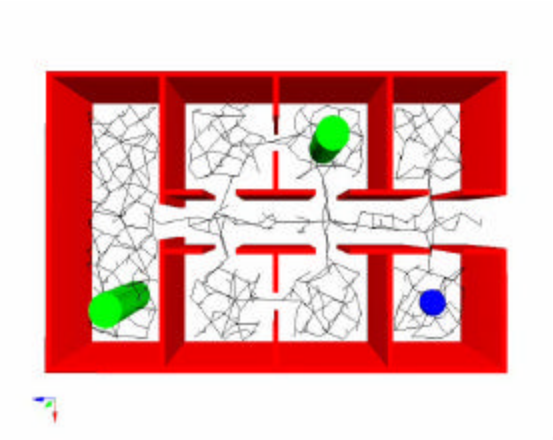
Changing environments

- **Dealing with moving obstacles**



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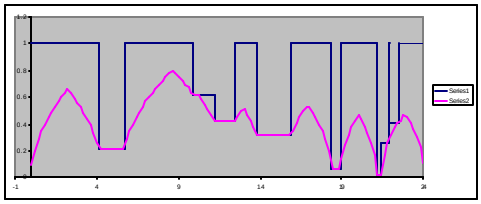
Camera Movement

- **Additional Constraints:**
  - The maximal speed with which an object can move depends on the curvature of the path
  - Also there is a maximal acceleration and deceleration
  - This leads to a speed diagram over the path



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Camera Movement

- **Viewing direction**
  - Look at the position you will be in 1 second time
  - Viewing direction function is C^2 continuous
- **Up vector**
  - Keep up-vector vertical
  - Limit the change in twist by reducing the speed

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Camera Movement

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Camera Movement

- **The mini map**
  - Using a map is not always possible
  - Using a map destroys the immersion in the environment
  - Direct indication of goals within the environment is preferred
- **Interrupting motions**
  - Is not yet supported
  - Topic for further research

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Label Placement

- **User needs information about**
  - Where he is
  - What direction to take to get to certain places
- **One solution is the use of labels**
  - What labels to use
  - Where to place the labels

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Label Placement

- The nodes in the navigation network are the important positions
- Here the choice of the user must be supported
- Labels must be visible
- Static or dynamic labels
- Combine with automatic motion

Further Research