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Application of Motion Planning to Human-Computer Interaction

Goal: Design an intelligent and practical interface that allows people to navigate in 3D on a computer.

- Intro to 3D navigation
  - Challenges:
    - Graphical realism: Computers generally show 45-90 degrees of view. Computers must be powerful to render realistic graphics.
    - Interactivity (framerate): Lower framerates lack precise control. A minimum of 15 fps is crucial.
    - Intuitivity (learning curve): Interface needs to make sense to the user.
    - Mechanical constraints: Computers feature a keyboard and a mouse, when our hands or voice would make more sense.
  - Types of navigation control: **1st person, out-of-body, third-person**
- Motion planning as assistance
  - Linear and rotational velocity are captured through mouse gestures.
  - Motion planning can be used to realize the true intention of the user by "correcting" the path the character follows in the environment.
    - If the user directs the character into a wall, the motion planner will develop a more intuitive path and follow that instead.
  - A searchable roadmap of the static environment is generated initially, which can be searched to quickly pathfind.
  - Time it takes for the user to navigate a maze can be reduced by ~70%.
- Extension to 3D full-body motion
  - Out-of-body control: Challenge is to efficiently motion-plan in 3D
    - Body of the character is decomposed into smaller elements
    - A small part of the path will be planned at once (budgeting)
    - 2D path is still generated for the base of the character. Motion for the upper body is planned in **CT (control+time) space**.
    - Result: Legs walk along the 2D path while arms, head, etc. avoid obstacles independently.
- Third-person control: Still not possible to efficiently plan full-body motions
  - Instead we reference a library of captured motions
    - **Motion Graph** shows nodes for each possible motion, connected by arcs that show feasible transitions.
    - Motion planner uses it to generate a **Feasible Motion Tree** showing which transitions make sense from current position
    - Tree is maintained a few steps in advance with a breadth-first search
    - Camera has several possible locations, one of which is also chosen to best view the charactter
- Conclusion: Despite challenges, practical algorithms and appropriate assumptions make it possible to assist a user in 3D navigation. CPU power should be used to power pathfinding rather than fancy graphics.