Scene Modeling for a Single View

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Portrait d'Edward James

…with a lot of slides stolen from Steve Seitz and David Brogan,
Breaking out of 2D

...now we are ready to break out of 2D

And enter the real world!
We want real 3D scene walk-throughs:
   Camera rotation
   Camera translation

Can we do it from a single photograph?
Camera rotations with homographies

Original image

Virtual camera rotations

St. Petersburg
photo by A. Tikhonov
Camera translation

Does it work?
Easy with planar scene (or far away)
Camera translation

Does it work?
So, what can we do here?

Model the scene as a set of planes!

Now, just need to find the orientations of these planes.
Ill posed problem.

Ames Room
Suppose
1. Our world is flat and the ground extends to infinity
2. You stand and look at north
3. What do you see?
Vanishing points

Vanishing point
- projection of a point at infinity
Vanishing points (2D)
Vanishing points

Properties

- Any two parallel lines have the same vanishing point $\mathbf{v}$
- The ray from $\mathbf{C}$ through $\mathbf{v}$ is parallel to the lines
- An image may have more than one vanishing point
Vanishing lines

Multiple Vanishing Points

- Any set of parallel lines on the plane define a vanishing point
- The union of all of these vanishing points is the *horizon line* — also called *vanishing line*
- Note that different planes define different vanishing lines
Computing vanishing lines

Properties

• $I$ is intersection of horizontal plane through $C$ with image plane
• Compute $I$ from two sets of parallel lines on ground plane
• All points at same height as $C$ project to $I$
  – points higher than $C$ project above $I$
• Provides way of comparing height of objects in the scene
Multiple Vanishing Points

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  - also called *vanishing line*
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Fun with vanishing points
“Tour into the Picture” (SIGGRAPH ’97)

Create a 3D “theatre stage” of five billboards

Specify foreground objects through bounding polygons

Use camera transformations to navigate through the scene
The idea

Many scenes (especially paintings), can be represented as an axis-aligned box volume (i.e. a stage)

Key assumptions:
- All walls of volume are orthogonal
- Camera view plane is parallel to back of volume
- Camera up is normal to volume bottom

How many vanishing points does the box have?
- Three, but two at infinity
- Single-point perspective

Can use the vanishing point to fit the box to the particular Scene!
Fitting the box volume

User controls the inner box and the vanishing point placement (# of DOF???)

Q: What’s the significance of the vanishing point location?
A: It’s at eye level: ray from COP to VP is perpendicular to image plane.
Example of user input: vanishing point and back face of view volume are defined
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Comparison of how image is subdivided based on two different camera positions. You should see how moving the box corresponds to moving the eyepoint in the 3D world.
Another example of user input: vanishing point and back face of view volume are defined.
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Another example of user input: vanishing point and back face of view volume are defined.
Comparison of two camera placements – left and right. Corresponding subdivisions match view you would see if you looked down a hallway.
2D to 3D conversion

First, we can get ratios

back plane

left

right

top

bottom

vanishing point
2D to 3D conversion

- Use top versus side ratio to determine relative height and width dimensions of box.
- Left/right and top/bot ratios determine part of 3D camera placement.
Depth of the box

Compute vertical angle between A and B from focal length.
Depth of the box

Compute vertical angles between A, B, and V from focal length.
DEMO

Now, we know the 3D geometry of the box
We can texture-map the box walls with texture from the image
Foreground Objects

Use separate billboard for each

For this to work, three separate images used:

- Original image.
- Mask to isolate desired foreground images.
- Background with objects removed
Foreground Objects

Add vertical rectangles for each foreground object.

Can compute 3D coordinates $P_0$, $P_1$ since they are on known plane.

$P_2$, $P_3$ can be computed as before (similar triangles).
Depth of the box
Depth of the box
Foreground DEMO
Final project

» 3/20: Proposal presentation in class.
» 4/5: Final project presentation
   (I likely have to skype)
» 4/8: Final report due

» Your research projects
» Implementation of papers.
» Extension of existing labs.