Rectilinear Parsing of Architecture in Urban Environment

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Outline

1. Introduction
2. Environment Parsing
3. Building Parsing
4. Unit Refinement
5. Experiments
Introduction

1. Introduction
   • Motivation and Problem
   • Overview

2. Environment Parsing

3. Building Parsing

4. Unit Refinement

5. Experiments
1.1 Motivation & Problem

Image-based City Modeling

- Digital earth applications
  - Google Earth
  - Microsoft Virtual Earth
- Games, Movies
1.1 Motivation & Problem

Parsing Architecture is a crucial step for image-based city modeling [Muller et al. 2007; Xiao et al. 2008; Xiao et al. 2009].
1.1 Motivation & Problem

- General Scenes
  - [Boutell et al 2007; Shotton et al 2009]
- Man-made object & Urban Scenes
  - [Han and Zhu 2005]
  - [Berg et al 2007; Hoiem et al 2008]
- Single Façade
  - [Muller et al 2007; Xiao et al 2008]
1.1 Motivation & Problem

Rectilinear Parsing of Architecture

- Buildings are parsed into units
- Each unit is with regular shape
1.2 Overview

1. The environment is parsed into buildings, ground and sky.
2. The building region is parsed into individual units, i.e. facades.
3. The boundary of each façade is regularized.
Environment Parsing

1. Introduction

2. Environment Parsing
   • Pre-processing
   • Buildings and ground
   • Sky

3. Building Parsing

4. Unit Refinement

5. Experiments
2.1 Pre-processing

- Quasi-dense Points
  - [Hartley and Zisserman 2003]
  - [Lhuillier and Quan 2005]
- Re-triangulated Line Segments
  - Canny Edge Detection [Canny 1986]
  - Line Extraction and Grouping [Baillard et al 1999; Sinha et al 2008]
  - Re-triangulation
2.2 Building and Ground
2.2 Building and Ground

Building Plane

Ground Plane

3D Ground Line
2.2 Building and Ground

3D Ground Line

2D Ground Line
2.2 Building and Ground
2.2 Building and Ground
2.3 Sky
2.3 Sky
2.3 Sky

1. Very few 3D points in sky regions.
2. Sky regions usually appear at the top boundary of the image.
2.3 Sky
Building Parsing

1. Introduction
2. Environment Parsing
3. Building Parsing
   • Formulation
   • Features
   • Optimization
4. Unit Refinement
5. Experiments
3.1 Formulation

Building region is over-partitioned into sub-facades (color-coded).
3.1 Formulation
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3.1 Formulation
3.1 Formulation

\[ E(\varphi_N^X) = \sum_{s \in X} d_{inter}(s) + \sum_{\zeta \in \varphi_N^X} d_{intra}(\zeta) \]
3.2 Features: Height & Appearance
3.2 Features: Intersections & Edge
3.3 Dynamic Programming Optimization
3.3 Dynamic Programming Optimization

$O(2^N)$

$O(N^3)$

$G$
3.3 Dynamic Programming Optimization

We define $G_i$ as the subgraph that only contains the first $i$ nodes of $G$. 
3.3 Dynamic Programming Optimization

When $G_i$ can only contain $j$ partitions, we define its optimal solution as $\phi_{i,j}$.

$\phi_{1,1}$

$\phi_{2,1}$

$\phi_{3,1}$
Known $\phi_{3,2}$ and $\phi_{3,1}$, how to get $\phi_{4,2}$?
3.3 Dynamic Programming Optimization

i=3; j=1,2

$\phi_{3,2}$

i=4; j=2

$\phi_{4,2}$

$\phi_{3,1}$

VS
3.3 Dynamic Programming Optimization
Unit Refinement

1. Introduction
2. Environment Parsing
3. Building Parsing
4. Unit Refinement
5. Experiments
4 Unit Refinement
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4 Unit Refinement

\[ \Gamma (e_{x,y}) = \alpha_e d_e (e_{x,y}) + \alpha_a d_a (e_{x,y}) + \alpha_d d_d (e_{x,y}) \]

- Edge
- Appearance
- Point Density
4 Unit Refinement

$$\Gamma (e_{x,y}) = \alpha_e d_e (e_{x,y}) + \alpha_a d_a (e_{x,y}) + \alpha_d d_d (e_{x,y})$$

- **Edge**
- **Appearance**
- **Point Density**
Experiments

5. Experiments
   • Results
   • Limitations
   • Conclusion
   • Future work
5.1 Results
5.1 Results

- Floor line
  - (midpoint, angle), (3.09 pixels, 1.41 degrees)
- Sky segmentation
  - 86.3%
- Building Partition
  - 85.1%
- Roof line
  - Average vertical offset, 4.02 pixels
5.2 Limitations

1. Occlusion, similar appearances and heights
2. Shadow
3. Sudden change of features in a single building
5.3 Conclusion

1. Building Partition
2. Unit Regularization
3. Evaluation
5.4 Future work

1. New features for partition
2. Arbitrary floor line and roof line parsing
3. Details parsing
Thank You!

Q & A