Assisted Object Placement

Master’s Thesis – Andreas Kirsch

computer graphics & visualization
Motivation
Background

Assisted Object Placement
Andreas Kirsch
Background

Assisted Object Placement
Andreas Kirsch
Shadowgrounds Survivor

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Andreas Kirsch

Goals
Goals

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Overview

Level Designer

- Query volume
  - Probe context query
  - Neighborhood context query

+ 

Candidate list
Probe context
Probe samples – Example
Probe samples – Color
Probe samples – Distance
Probe samples – Occlusion
Probe placement
Probe placement
Probe placement

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Probe placement – All directions
Probe placement – Relative position
Probe placement – Neighbors
Probe placement – Neighbors
Probe placement – Avg normals
Probe placement – Avg normals
Probe placement – Combined
Queries

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Bidirectional match query
Bidirectional match query

\[ S = \frac{\# \text{matches model}}{\# \text{samples model}} \cdot \frac{\# \text{matches query}}{\# \text{samples query}} \]
Importance-weighted queries
Importance-weighted queries

\[ h(X) = - \ln P(X) \]
Configuration query
Configuration query
Algorithms

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Naive implementation
Naive implementation
Naive implementation

Dataset B

Dataset A
Optimizations

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First optimization

Dataset B

Dataset A
First optimization

Dataset B

Dataset A
First optimization
First optimization

Dataset B

Dataset A
First optimization

Dataset B

Dataset A
Second optimization

<table>
<thead>
<tr>
<th>Color</th>
<th>Distance</th>
<th>Occlusion</th>
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<tbody>
<tr>
<td>8+8+8 bits</td>
<td>8 bits</td>
<td>8 bits</td>
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Second optimization

- **Color**: 3+4+4 bits
- **Distance**: 3-5 bits
- **Occ**: 2-3 bits

- **Total before optimization**: 8+8+8 bits
- **Total after optimization**: 3+4+4 bits + 3-5 bits + 2-3 bits
Second optimization

Packed probe sample
bit set
Second optimization

Packed probe sample sequence

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Second optimization

Sampled model

Query volume
Second optimization

Sampled model

Query volume

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Second optimization

Sampled model

Query volume
Second optimization
Second optimization

Sampled model

Query volume
Second optimization

Sampled model

Query volume

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Second optimization

Sampled model

Query volume
Second optimization

Sampled model

Query volume
Neighborhood context
Neighborhood context
Neighborhood context
Neighborhood context
Comparing neighborhoods
Comparing neighborhoods
Comparing neighborhoods
Matching distance groups
Matching distance groups

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Matching distance groups

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Andreas Kirsch
Matching distance groups
Matching distance groups

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## Similarity measures

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Rand similarity measure

\[ R = \frac{m_{11} + m_{00}}{m_{11} + m_{10} + m_{01} + m_{00}} \]

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Rand similarity measure

\[ R = \frac{m_{11} + m_{00}}{m_{11} + m_{10} + m_{01} + m_{00}} \]

\[
\begin{array}{cccccccc}
 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\
\cdot & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\
\square_1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\
\square_2 & 1 & 1 & 1 & 0 & 1 & 0 & 0 \\
\bigcirc & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\
\end{array}
\]

\[ = \frac{4}{6} \]
## Rand similarity measure

\[ R = \frac{m_{11} + m_{00}}{m_{11} + m_{10} + m_{01} + m_{00}} \]

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<thead>
<tr>
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\[ = \frac{2}{6} \]
Rand similarity measure

\[ R = \frac{m_{11} + m_{00}}{m_{11} + m_{10} + m_{01} + m_{00}} \]

\[
\begin{array}{ccccccc}
\cdot & 0 & 1 & 0 & 1 & 0 & 0 \\
\square_1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\
\square_2 & 1 & 1 & 1 & 0 & 1 & 0 & 0 \\
\bigcirc & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\
\end{array}
\]

\[ = \frac{3}{6} \]
Jaccard index

\[ R = \frac{m_{11}}{m_{11} + m_{10} + m_{01}} \]

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Jaccard index

\[ R = \frac{m_{11}}{m_{11} + m_{10} + m_{01}} \]

\[
\begin{array}{cccccccc}
. & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\
\hline
\square_1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\
\square_2 & 1 & 1 & 1 & 0 & 1 & 0 & 0 \\
\bigcirc & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\
\end{array}
\]

\[ = \frac{1}{3} \]
Jaccard index

\[ R = \frac{m_{11}}{m_{11} + m_{10} + m_{01}} \]

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\[ = \frac{1}{5} \]
Jaccard index

\[ R = \frac{m_{11}}{m_{11} + m_{10} + m_{01}} \]

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\[ = \frac{1}{4} \]
Importance-weighted Rand measure

\[
R = \frac{\sum \Phi_k \mathbb{1}_{\{\text{query}_k = \text{instance}_k\}}}{\sum \Phi_k}
\]

\[\Phi_k = h(\text{query}_k) + h(\text{instance}_k)\]
Importance-weighted Rand measure

\[ R = \frac{\sum \Phi_k \mathbb{1}_{\{\text{query}_k = \text{instance}_k\}}}{\sum \Phi_k} \]

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<td>1</td>
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</tbody>
</table>
Importance-weighted Rand measure

\[ R = \frac{\sum \Phi_k \mathbb{1}_{\{query_k = instance_k\}}}{\sum \Phi_k} \]

\[ = \frac{\Phi_1 + \Phi_3 + \Phi_4 + \Phi_6}{\sum \Phi_k} \]
Importance-weighted Rand measure

\[ R = \frac{\sum \Phi_k \mathbb{I}_{\{\text{query}_k = \text{instance}_k\}}}{\sum \Phi_k} \]

\[ \begin{array}{ccccccc}
\bullet & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\
\square_1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\
\square_2 & 1 & 1 & 1 & 0 & 1 & 0 & \text{c}\text{c}\text{c} \\
\bigcirc & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\
\end{array} \]

\[ = \Phi_2 + \Phi_6 \]
Importance-weighted Rand measure

\[
R = \frac{\sum \Phi_k \mathbb{1}_{\{\text{query}_k = \text{instance}_k\}}}{\sum \Phi_k}
\]

\[
\begin{array}{cccccc}
0 & 1 & 0 & 1 & 0 & 0 \\
\begin{array}{cccccc}
\square_1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\
\square_2 & 1 & 1 & 1 & 0 & 1 & 1 & 0 \\
\end{array}
\end{array}
\]

\[
= \frac{\Phi_1 + \Phi_3 + \Phi_4}{\sum \Phi_k}
\]
Combining context scores
Combining context scores
Combining context scores

\[ S_{\text{final}} = S_{\text{probe}} \cdot S_{\text{neighborhood}} \]
Results

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Validation
marin01_wakeup
Validation: probe context

<table>
<thead>
<tr>
<th># models</th>
<th># instances</th>
<th>avg rank (model frequency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>marine02_road</td>
<td>94</td>
<td>1396</td>
</tr>
<tr>
<td>marine01_wakeup</td>
<td>150</td>
<td>2066</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level</th>
<th>marine02_road</th>
<th>marine02_road (5)</th>
<th>marine01_wakeup</th>
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<tbody>
<tr>
<td>Uniform bidirectional match</td>
<td>14.1</td>
<td>17.7</td>
<td>15.2</td>
</tr>
<tr>
<td>IW bidirectional match</td>
<td>12.9</td>
<td>17.6</td>
<td>14.3</td>
</tr>
<tr>
<td>Configuration</td>
<td>10.5</td>
<td>16.0</td>
<td>10.4</td>
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</table>
Validation: neighborhood context

<table>
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<th># instances</th>
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<td>17.15</td>
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<td>marine01_wakeup</td>
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<td>2066</td>
<td>21.10</td>
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<table>
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<th>Max random shift</th>
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<tr>
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<td>60</td>
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<td></td>
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<td>20</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>20</td>
<td>60</td>
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<tr>
<td>Rand measure</td>
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<td>0.43</td>
<td>0.46</td>
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<tr>
<td>IW measure</td>
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<td>0.42</td>
<td>0.45</td>
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<tr>
<td>Jaccard index</td>
<td>0.38</td>
<td>0.43</td>
<td>0.46</td>
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Validation: combined contexts

<table>
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<th># models</th>
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<td>marine02_road</td>
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<td>1396</td>
</tr>
<tr>
<td>marine01_wakeup</td>
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<td>2066</td>
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<table>
<thead>
<tr>
<th>marine02_road</th>
<th>marine02_road (5)</th>
<th>marine01_wakeup</th>
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</thead>
<tbody>
<tr>
<td>Rand</td>
<td>IW</td>
<td>Jaccard</td>
</tr>
<tr>
<td>Uniform bidirectional</td>
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<td>IW bidirectional</td>
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<td>Configuration</td>
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## Performance

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<th>Importance-weighted measure</th>
<th>Jaccard index</th>
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<td>marine01_wakeup</td>
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<tr>
<td>marine02_road (5)</td>
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<td>93</td>
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<tr>
<td>marine01_wakeup</td>
<td>2.4</td>
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<td>1500</td>
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Summary
Post Mortem

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Questions?
Demo