Detecting Fine-grained Affordances with an Anthropomorphic Agent Model

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COMPUTERVISUALISTIK

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AGAS

Motivation and Contribution

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- current approaches distinguish affordances on a coarse scale
- fine-grained affordances allow for detailed scene analysis

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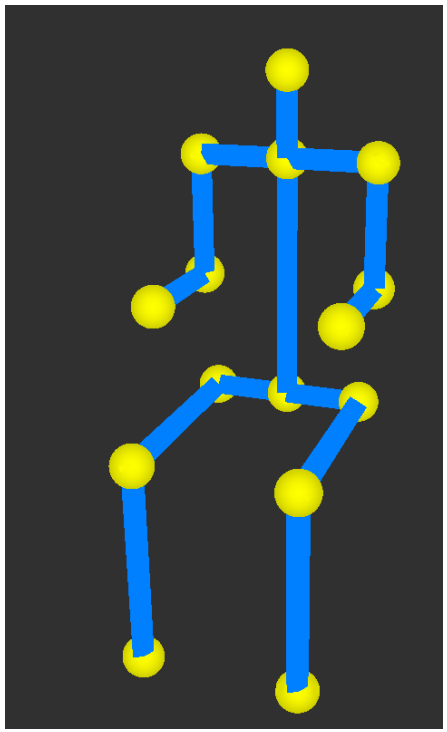
Contribution (and outline)

1. anthropomorphic agent model for
2. fine-grained affordance detection
3. first results on affordances derived from *sitting*

Anthropomorphic Agent Model

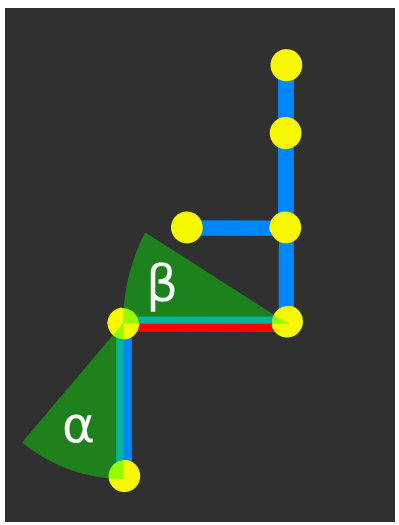
- directed acyclic graph
- non-leave nodes:
  joints, movement restrictions
- edges: parameterized spatial relations between joints
- models typical human body proportions



Affordance Models

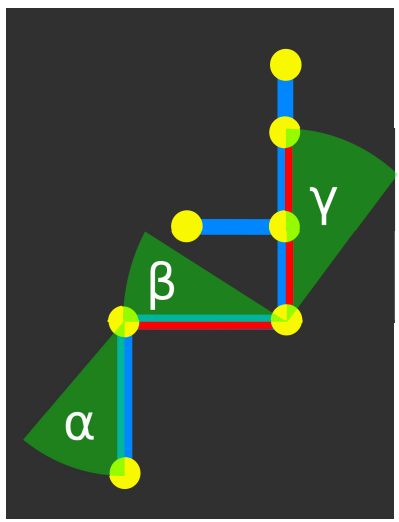
Sitting without backrest

- α, β determine valid heights
- support has to be present in *contact area* (red)
- feet must touch the ground



Sitting with backrest

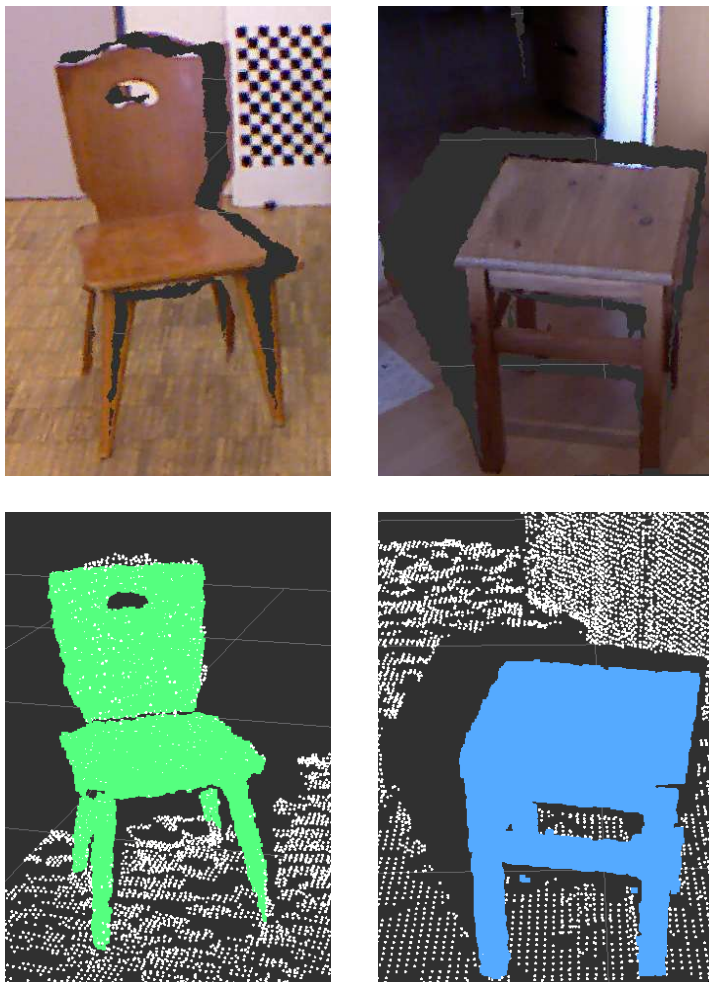
- γ determines valid plane inclination
- additional contact area for back support



Fine-grained Affordance Detection

- input: point cloud of the scene
- output: point cloud with segmented affordances

1. segment planes in input
2. check *sitting w/o backrest* model parameters for horizontal planes
3. collect planes supporting parameters
4. for each of these planes: check *sitting with backrest* model parameters
5. assign affordance category based on supported parameters



Experiments

Dataset (acquired in our lab)

- 17 chairs and 3 stools to represent fine-grained affordances
- 247 (chairs) and 47 (stools) different views extracted
- negative data from 9 different objects (109 views extracted)
- negative data: bed, desks, tables, dressers and a heating element
- whole dataset: 403 scene views (294 positive and 109 negative)

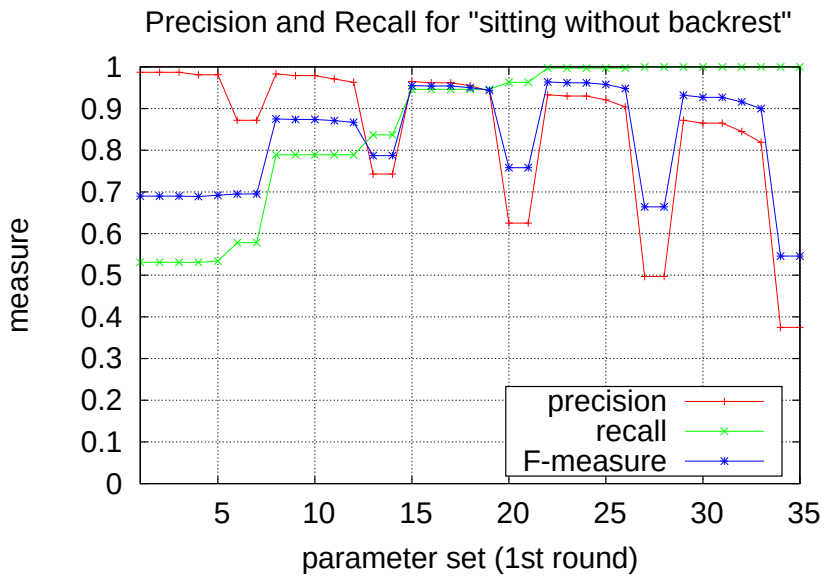
Experiments

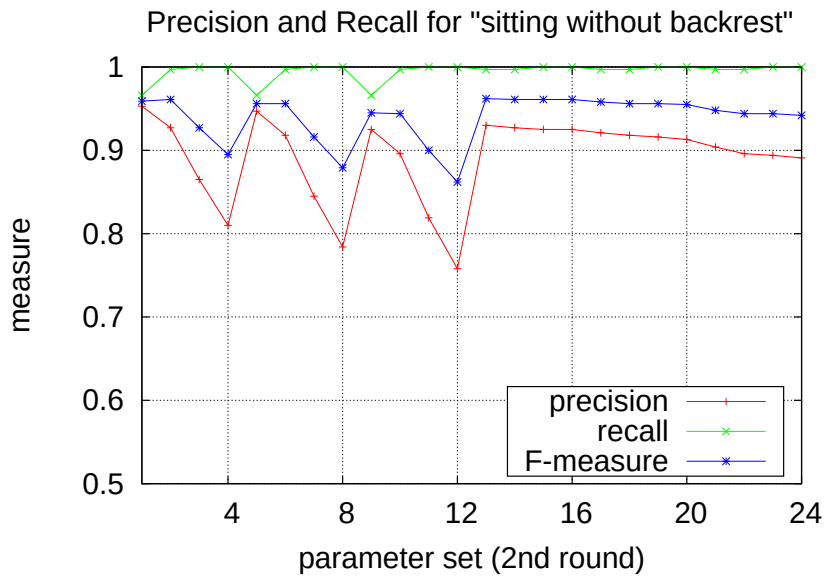
Parameters

- angle parameters: α, β, γ
- model parameters: D_{min}, D_{max}
- 59 different parameter sets in 2 rounds
- first round: parameters varied over a wide range
- second round: parameter sets close to best parameters from first round
- evaluation using the F-measure
  (harmonic mean between precision and recall)

$$\text{F-measure} = \frac{2 \cdot \text{precision} \cdot \text{recall}}{\text{precision} + \text{recall}}$$

Results





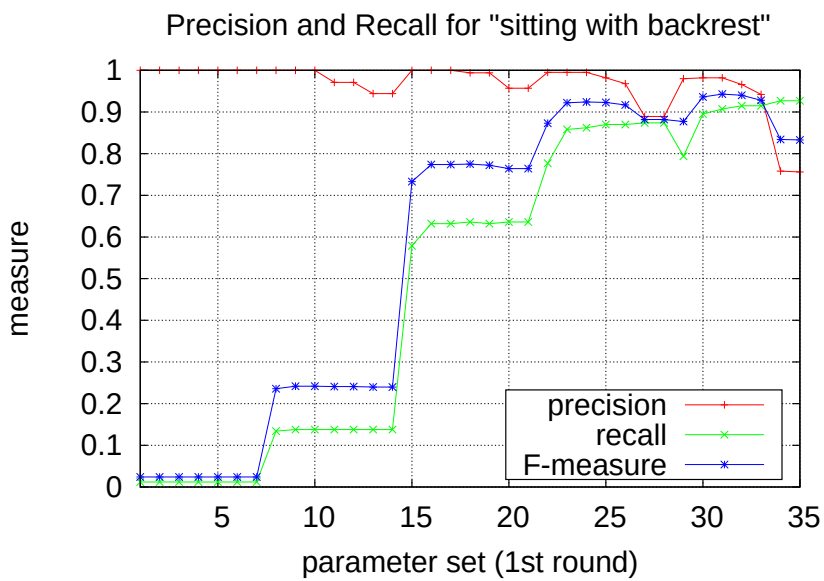
param. set	α	β	D_{min}	D_{max}
1	20	20	0.8	1.1
2	25	25	0.8	1.1
7	50	50	0.8	1.1
29	20	20	0.4	1.5
35	50	50	0.4	1.5

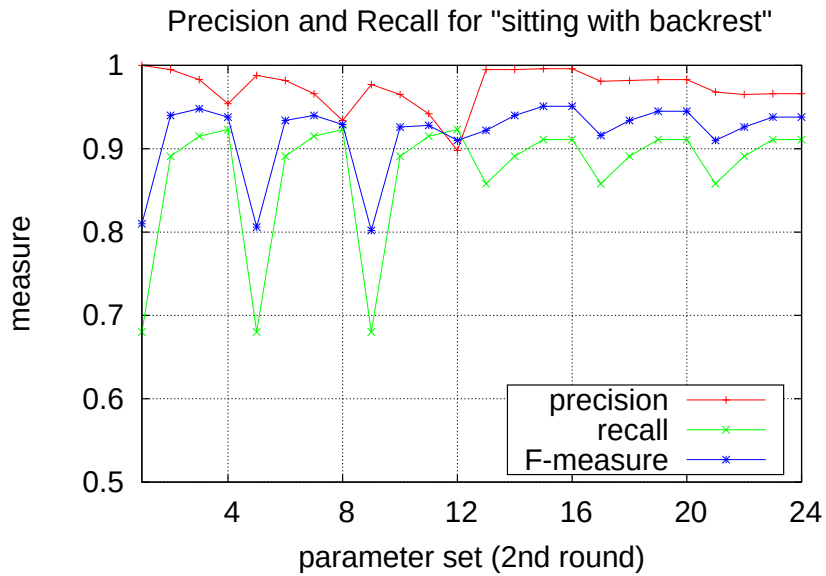
	α	β	D_{min}	D_{max}
1	30	30	0.6	1.5
2	30	30	0.5	1.5
3	30	30	0.4	1.5
4	30	30	0.3	1.5
21	40	40	0.5	1.4
24	40	40	0.5	1.7

- “valleys”: high angles (> 40°)
- “plateaus”: angles between 20° and 40°

- lower values for decreasing D_{min}
- almost stable for increasing D_{max}

Results





param. set	γ	D_{min}	D_{max}
1	20	0.8	1.1
2	25	0.8	1.1
7	50	0.8	1.1
29	20	0.4	1.5
35	50	0.4	1.5

	γ	D_{min}	D_{max}
1	25	0.6	1.5
2	30	0.5	1.5
3	35	0.4	1.5
4	40	0.3	1.5
21	25	0.5	1.4
24	40	0.5	1.7

- very sensitive to D_{min} and D_{max}
- little influence by γ

- lower values for high D_{min}
- higher values for increasing D_{max}

Results

Best F-measure values:

	sit. w/o backrest	sit. with backrest
best w/o backr.	0.962	0.922
best with backr.	0.961	0.951

Best parameters:

α, β	γ	D_{min}	D_{max}
30°	35°-40°	0.5	1.4-1.6

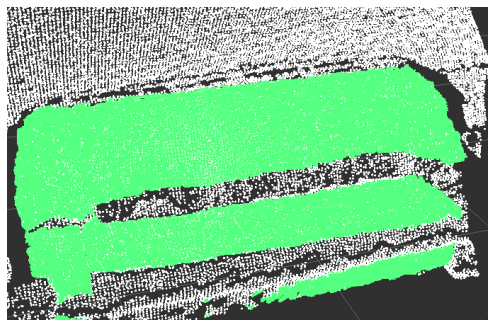
Conclusion & Outlook

Conclusion

- first results are promising
- fine-grained affordances allow for distinguishing between stool and chair

Outlook

- agent-centered vs. feature-centred approach
- use fuzzy logic
- include more fine-grained affordances (for sitting and other affordances)



Thank you for your interest!

Algorithm 1 Fine-grained Affordance Detection.

Require: Point cloud $\mathcal{P}$, Affordance models f_1, f_2, Agent model $\mathcal{H}$
Ensure: Point cloud with segmented affordances $\mathcal{P}_1$ and $\mathcal{P}_2$

$\mathcal{E} \leftarrow segmentPlanes(\mathcal{P})$
$S \leftarrow \emptyset$
for all horizontal planes $p \in \mathcal{E}$ **do**
  if $supportsModels(p, \mathcal{H}, f_1)$ **then**
    $S \leftarrow S \cup p$
  end if
end for
for all $s \in S$ **do**
  $V \leftarrow$ vertical planes $\in \mathcal{E}$ close to s
  if $supportsModels(v, \mathcal{H}, f_2)$ **and** v is biggest plane $\in V$ that supports the models **then**
    $\mathcal{P}_2 \leftarrow \mathcal{P}_2 \cup v$
    $\mathcal{P}_2 \leftarrow \mathcal{P}_2 \cup s$
  else
    $\mathcal{P}_1 \leftarrow \mathcal{P}_1 \cup s$
  end if
end for

Parameters for 1st round of evaluation

	α	β	γ	D_{min}	D_{max}
1	20	20	20	0.8	1.1
2	25	25	25	0.8	1.1
3	30	30	30	0.8	1.1
4	35	35	35	0.8	1.1
5	40	40	40	0.8	1.1
6	45	45	45	0.8	1.1
7	50	50	50	0.8	1.1
8	20	20	20	0.7	1.2
9	25	25	25	0.7	1.2
10	30	30	30	0.7	1.2
11	35	35	35	0.7	1.2
12	40	40	40	0.7	1.2
13	45	45	45	0.7	1.2
14	50	50	50	0.7	1.2
15	20	20	20	0.6	1.3
16	25	25	25	0.6	1.3
17	30	30	30	0.6	1.3
18	35	35	35	0.6	1.3
19	40	40	40	0.6	1.3
20	45	45	45	0.6	1.3
21	50	50	50	0.6	1.3

	α	β	γ	D_{min}	D_{max}
22	20	20	20	0.5	1.4
23	25	25	25	0.5	1.4
24	30	30	30	0.5	1.4
25	35	35	35	0.5	1.4
26	40	40	40	0.5	1.4
27	45	45	45	0.5	1.4
28	50	50	50	0.5	1.4
29	20	20	20	0.4	1.5
30	25	25	25	0.4	1.5
31	30	30	30	0.4	1.5
32	35	35	35	0.4	1.5
33	40	40	40	0.4	1.5
34	45	45	45	0.4	1.5
35	50	50	50	0.4	1.5

Parameters for 2nd round of evaluation

	α	β	γ	D_{min}	D_{max}
1	30	30	25	0.6	1.5
2	30	30	30	0.5	1.5
3	30	30	35	0.4	1.5
4	30	30	40	0.3	1.5
5	35	35	25	0.6	1.5
6	35	35	30	0.5	1.5
7	35	35	35	0.4	1.5
8	35	35	40	0.3	1.5
9	40	40	25	0.6	1.5
10	40	40	30	0.5	1.5
11	40	40	35	0.4	1.5
12	40	40	40	0.3	1.5

	α	β	γ	D_{min}	D_{max}
13	30	30	25	0.5	1.4
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18	35	35	30	0.5	1.5
19	35	35	35	0.5	1.6
20	35	35	40	0.5	1.7
21	40	40	25	0.5	1.4
22	40	40	30	0.5	1.5
23	40	40	35	0.5	1.6
24	40	40	40	0.5	1.7