3D Semantic Segmentation of Modular Furniture using rjMCMC

Supplementary Material

Anonymous WACV submission

Paper ID 63

1. Jacobian for Trans-dimensional Moves

In rjMCMC, to achieve stationary distribution, Jacobian term is added in the acceptance probability to balance the dimensions of the current state $\mathbf{S}$ and next state $\mathbf{S}^*$ [1].

$$J = \frac{\partial(\mathbf{S}, \mathbf{U})}{\partial(\mathbf{S}^*, \mathbf{V})} = det \begin{bmatrix} \frac{\partial \mathbf{S}^*}{\partial \mathbf{S}} & \frac{\partial \mathbf{V}}{\partial \mathbf{S}} \\ \frac{\partial \mathbf{S}^*}{\partial \mathbf{U}} & \frac{\partial \mathbf{V}}{\partial \mathbf{U}} \end{bmatrix}$$

Where $\mathbf{U}$ and $\mathbf{V}$ are auxiliary variables sampled independently of $\mathbf{S}$, $\mathbf{S}^*$ respectively s.t. $\dim(\mathbf{S}) + \dim(\mathbf{U}) = \dim(\mathbf{S}^*) + \dim(\mathbf{V})$, $\mathbf{S}^* := \mathbf{g}(\mathbf{S}, \mathbf{U})$, $\mathbf{S} := \mathbf{h}(\mathbf{S}^*, \mathbf{V})$. Here, g and h are deterministic functions.

1.1. Birth Move

For the birth of a new rectangle, let assume that the current state $\mathbf{S}$ has two rectangles $\mathbf{r_1}, \mathbf{r_2}$ and the proposed state $\mathbf{S}^*$ after birth move has three rectangles $\mathbf{r_1^*}, \mathbf{r_2^*}, \mathbf{r_3^*}$. The state transition is given by,

$$\{\mathbf{S}\} \rightarrow \{\mathbf{S}^*\}$$

$$\{\mathbf{r_1}, \mathbf{r_2}, \mathbf{U}\} \rightarrow \{\mathbf{r_1^*} = \mathbf{r_1}, \mathbf{r_2^*} = \mathbf{r_2}, \mathbf{r_3^*}\}$$

If $\mathbf{U}$ is sampled from the rectangle proposal pool such that $\mathbf{U} = \mathbf{r_3}$, then the Jacobian corresponding to birth move boils down to,

$$\mathbf{J_{birth}} = \mathbf{det} \begin{bmatrix} \frac{\partial \mathbf{r_1^*}}{\partial \mathbf{r_1}} & \frac{\partial \mathbf{r_1^*}}{\partial \mathbf{r_2}} & \frac{\partial \mathbf{r_1^*}}{\partial \mathbf{U}} \\ \frac{\partial \mathbf{r_2^*}}{\partial \mathbf{r_1}} & \frac{\partial \mathbf{r_2^*}}{\partial \mathbf{r_2}} & \frac{\partial \mathbf{r_2^*}}{\partial \mathbf{U}} \\ \frac{\partial \mathbf{r_3^*}}{\partial \mathbf{r_1}} & \frac{\partial \mathbf{r_3^*}}{\partial \mathbf{r_2}} & \frac{\partial \mathbf{r_3^*}}{\partial \mathbf{U}} \end{bmatrix} = \mathbf{det} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = \mathbf{1} \tag{1}$$

1.2. Death Move

Similarly, let the current state $\mathbf{S}$ has three rectangles $\mathbf{r_1}, \mathbf{r_2}, \mathbf{r_3}$ and the proposed state $\mathbf{S}^*$ after death move has two rectangles $\mathbf{r_1^*}, \mathbf{r_2^*}$

$$\{\mathbf{S}\} \rightarrow \{\mathbf{S}^*\}$$

$$\{\mathbf{r_1}, \mathbf{r_2}, \mathbf{r_3}\} \rightarrow \{\mathbf{r_1^*} = \mathbf{r_1}, \mathbf{r_2^*} = \mathbf{r_2}, \mathbf{V}\}$$

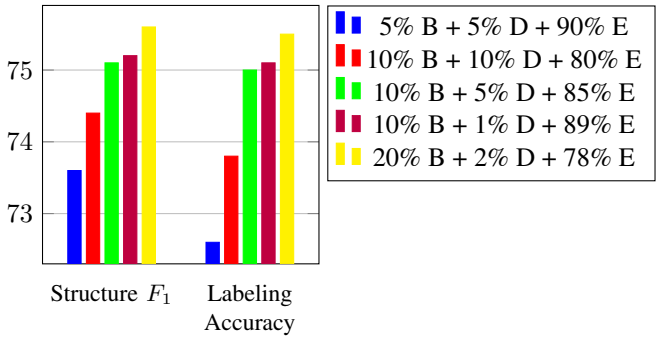
The Jacobian of death move is hence given by

$$\mathbf{J_{death}} = \mathbf{det} \begin{bmatrix} \frac{\partial \mathbf{r_1^*}}{\partial \mathbf{r_1}} & \frac{\partial \mathbf{r_1^*}}{\partial \mathbf{r_2}} & \frac{\partial \mathbf{r_1^*}}{\partial \mathbf{r_3}} \\ \frac{\partial \mathbf{r_2^*}}{\partial \mathbf{r_1}} & \frac{\partial \mathbf{r_2^*}}{\partial \mathbf{r_2}} & \frac{\partial \mathbf{r_2^*}}{\partial \mathbf{r_3}} \\ \frac{\partial \mathbf{V}}{\partial \mathbf{r_1}} & \frac{\partial \mathbf{V}}{\partial \mathbf{r_2}} & \frac{\partial \mathbf{V}}{\partial \mathbf{r_3}} \end{bmatrix} = \mathbf{det} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = \mathbf{1} \tag{2}$$

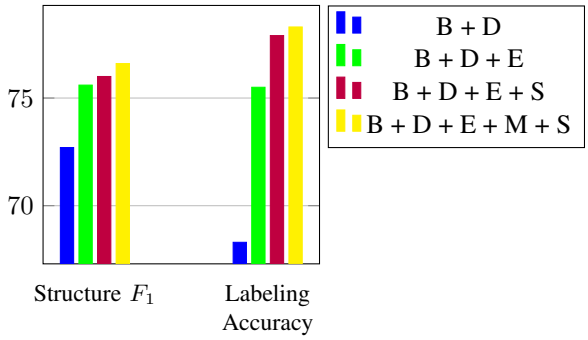
2. Experiments

Effect of Jump Diffusion Moves. Effect of each moves is investigated in detail. Figure 1b indicates that the combination of birth and death move achieves a labeling accuracy just 9% less than the maximum achieved accuracy. This shows that birth and death moves have very significant contribution to structure formation as well as label inference. To study the effect of exchange move, the combination of birth, death and exchange was tried. It can be noted from Figure 1b that the inclusion of exchange moves resulted in approximately 2% boost in structure and label performance.

An experiment with the combination of birth, death and exchange moves is performed to fix the relative number of birth and death iterations. Different probability distribution of these three moves are tried out. The results are shown in Figure 1a. It is to be noted that, the performance is better when birth moves are prioritized over death moves.



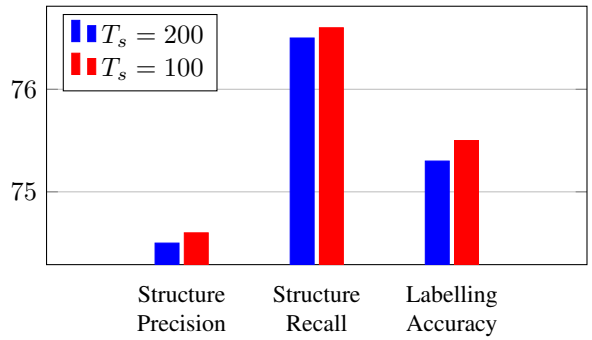
(a) Bar graph showing different propotion of moves.



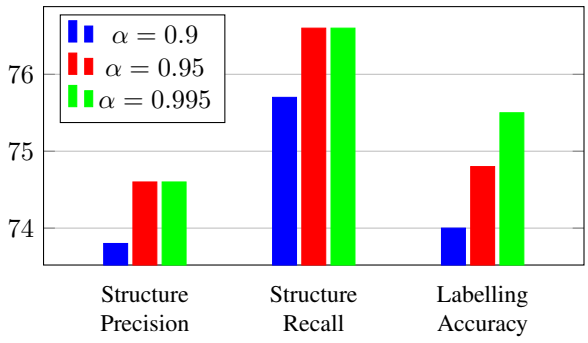
(b) Bar graph showing different combinations of moves

Figure 1: Here B is birth, D is death and E is exchange moves. (a) Performance is better when birth moves are prioritized over death moves. (b) Performance is better when all kind of moves along wiht split and merge augmentation are used.

Simulated Annealing Parameters. The impact of simulated annealing parameters are studied. Figures 2a and 2b display the results of these experiments. It is clear from Figure 2b that the geometric cooling parameter α has a significant impact. experiment shows that the faster cooling is better.



(a) For constant $\alpha = 0.95$, two different temperature is tested. Higher temperature is better but takes longer time to converge.



(b) For fixed initial temperature $T_s = 100$, three different values of cooling parameter (α) are tested. Faster cooling improves the performance.

Figure 2: Effect of simulated annealing parameters.

References

[1] P. J. Green. Reversible jump markov chain monte carlo computation and bayesian model determination. *Biometrika*, 82:711–732, 1995.

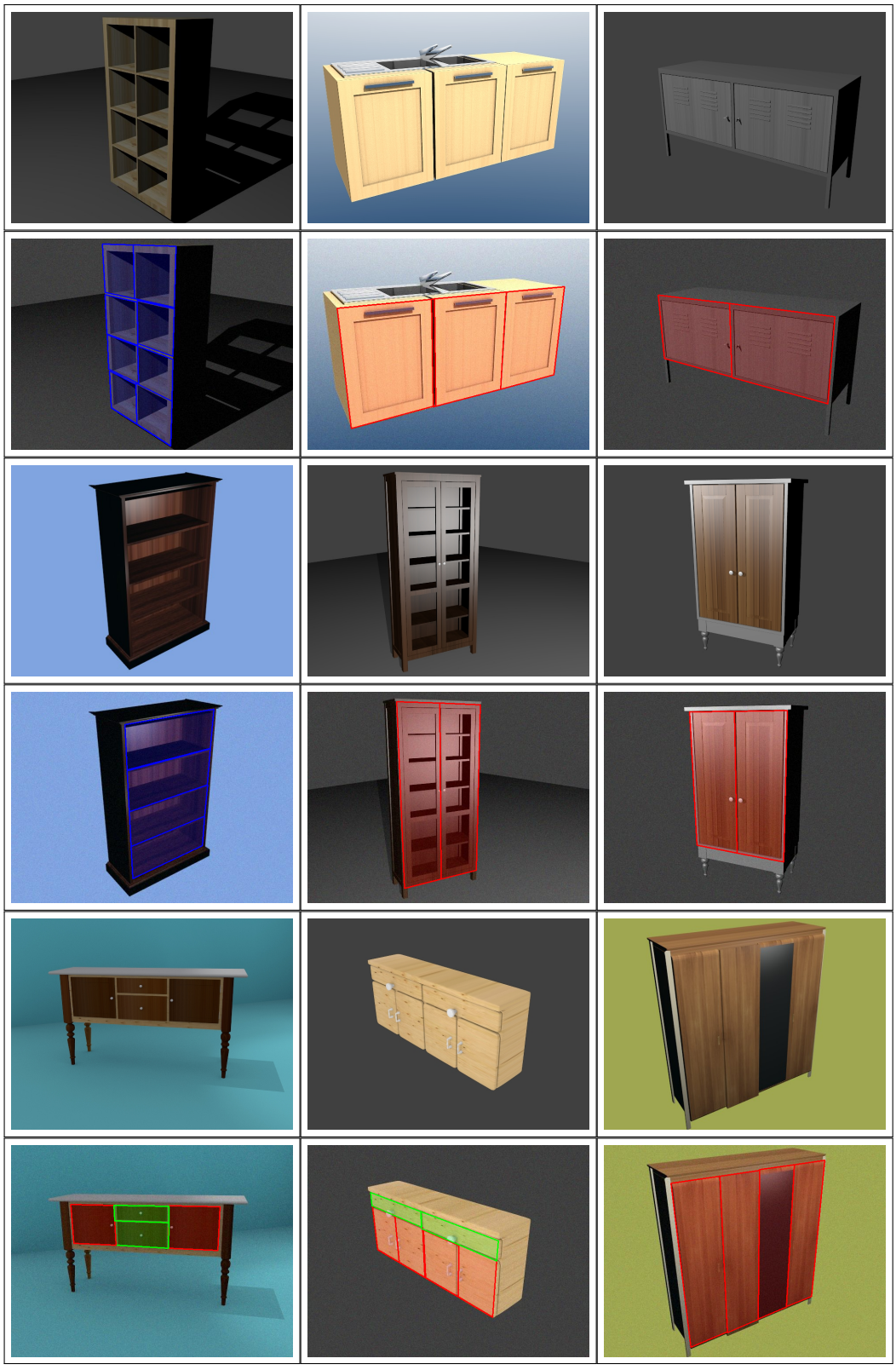


Figure 3: More qualitative results: success cases. (door, drawer and shelf).

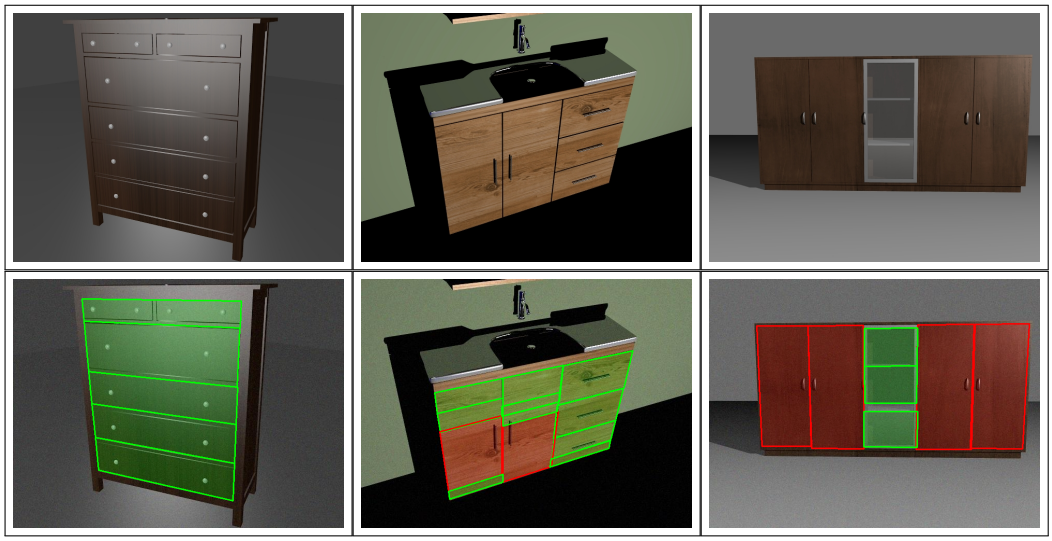


Figure 4: More qualitative results: Failed cases: The two main reasons for failure are missed edges and over segmentation due to complex texture. (door, drawer and shelf).