Appendix

A. Detail of geometry constraint loss

0.0.1 Forward

We consider four groups of bones, defined by $G = \{\text{arm, leg, shoulder, hip}\}$.

- $R_{\text{arm}} = \{\text{left lower arm, left upper arm, right lower arm, right upper arm}\}$,
- $R_{\text{leg}} = \{\text{left lower leg, left upper leg, right lower leg, right upper leg}\}$,
- $R_{\text{shoulder}} = \{\text{left shoulder bone, left shoulder bone}\}$,
- $R_{\text{hip}} = \{\text{left hip bone, left hip bone}\}$.

A bone (e.g. left lower arm) is represented by the index of its two end-points, $e = (j_L, j_R)$, i.e., left lower arm = (left wrist, left elbow). Let $Y_{2D}^{(j)} = (u(j), v(j))$, we have

$$l_e = ||Y_{3D}^{(j_L)} - Y_{3D}^{(j_R)}|| = \sqrt{(u(j_L) - u(j_R))^2 + (v(j_L) - v(j_R))^2 + (Y_{3D}^{(j_L)} - Y_{3D}^{(j_R)})^2}$$

Reminder that $\bar{l}_e$ is a pre-defined constant, we have

$$L_{geo}(Y_{dep}|Y_{2D}) = \sum_{i \in G} \frac{1}{|R_i|} \sum_{e \in R_i} (\frac{l_e}{\bar{l}_e} - \bar{r}_i)^2,$$

where

$$\bar{r}_i = \frac{1}{|R_i|} \sum_{e \in R_i} \frac{l_e}{\bar{l}_e}.$$

0.1. Backward

$$\frac{\partial L_{geo}}{\partial l_e} = \frac{\partial}{\partial l_e} \sum_{i \in G} \frac{1}{|R_i|} \sum_{e \in R_i} (\frac{l_e}{\bar{l}_e} - \bar{r}_i)^2
= \frac{\partial}{\partial l_e} \sum_{i \in G} (\frac{1}{|R_i|} \sum_{e \in R_i} (\frac{l_e}{\bar{l}_e})^2 - (\frac{1}{|R_i|} \sum_{e \in R_i} l_e)^2)
= \sum_{i \in G} \frac{2}{|R_i|} \sum_{e \in R_i} (\frac{l_e}{\bar{l}_e} - \bar{r}_i)$$

Let $e = (j, j')$

$$\frac{\partial l_e}{\partial Y_{dep}^{(j)}} = \frac{1}{l_e} (Y_{dep}^{(j)} - Y_{dep}^{(j')})$$

So we have

$$\frac{\partial L_{geo}}{\partial Y_{dep}^{(j)}} = \frac{\partial L_{geo}}{\partial l_e} \frac{\partial l_e}{\partial Y_{dep}^{(j)}} = \sum_{i \in G} \frac{2}{|R_i|} \sum_{e \in R_i} \frac{l_e}{\bar{l}_e} (Y_{dep}^{(j)} - Y_{dep}^{(j')})$$

1. More Qualitative results
Table 1. Qualitative results from MPII validation 3D sets. We show our predicted poses and our annotated poses (Section 4). Our framework performs well in a wide range of poses and situations. Typical failure cases (the last three lines) include inaccurate 2D prediction, ambiguous depth, and false torso length.