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Abstract: Human gait is a complex and essential pattern of movements for mobility. Moreover, many types of diseases (neurological, muscular, orthopedic, etc.) can be diagnosed from gait analysis. This paper introduces a novel method to quickly visualize (a)symmetric motion of different body parts of a **patient walking on a treadmill** for daily clinical usage. The method relies on the analysis of **depth maps** provided by a low-cost easy-to-use depth sensor.

Method

Step 1: Converting a depth map to 3D points

Step 2: Human silhouette segmentation

Step 3: Dimensionality reduction to a 3D color space

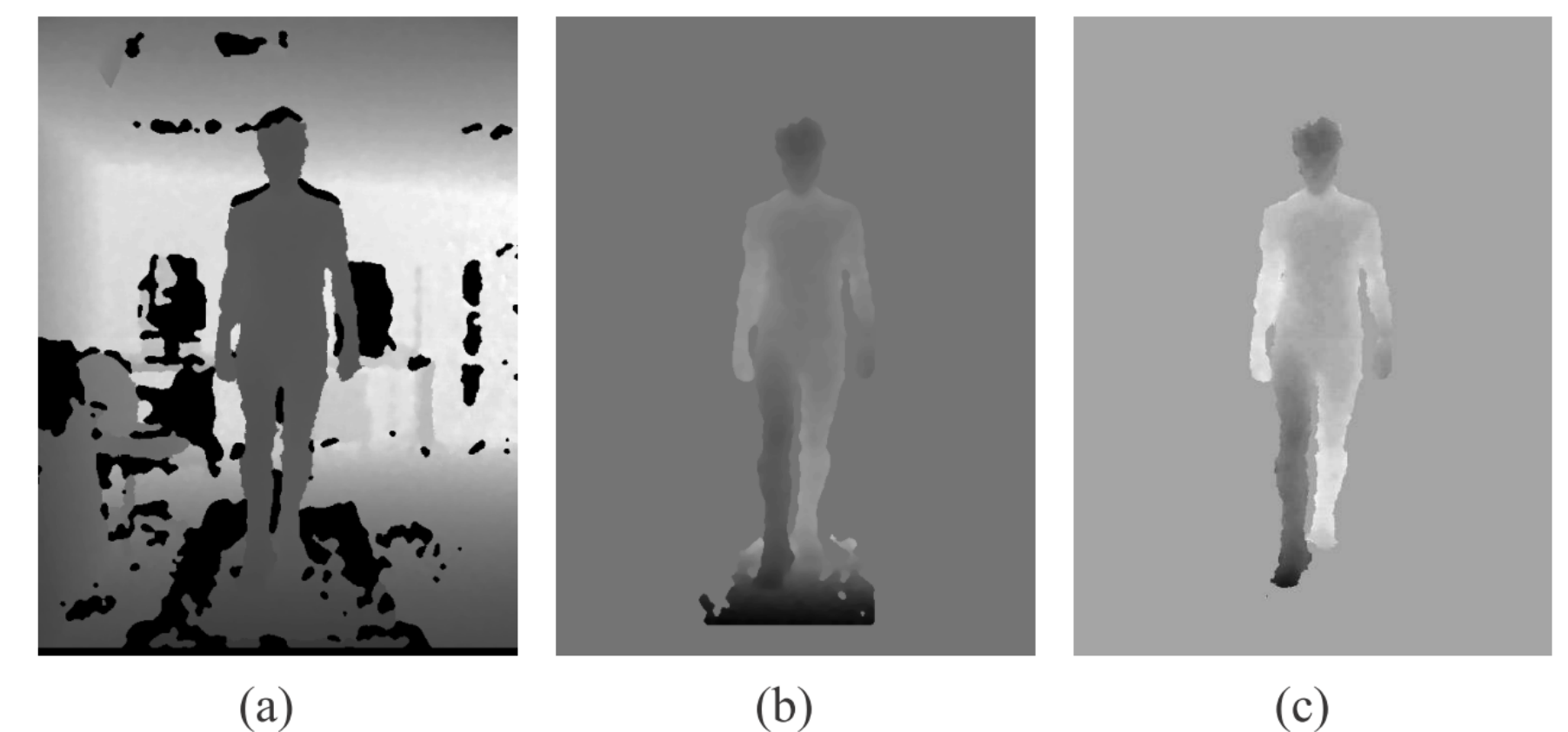
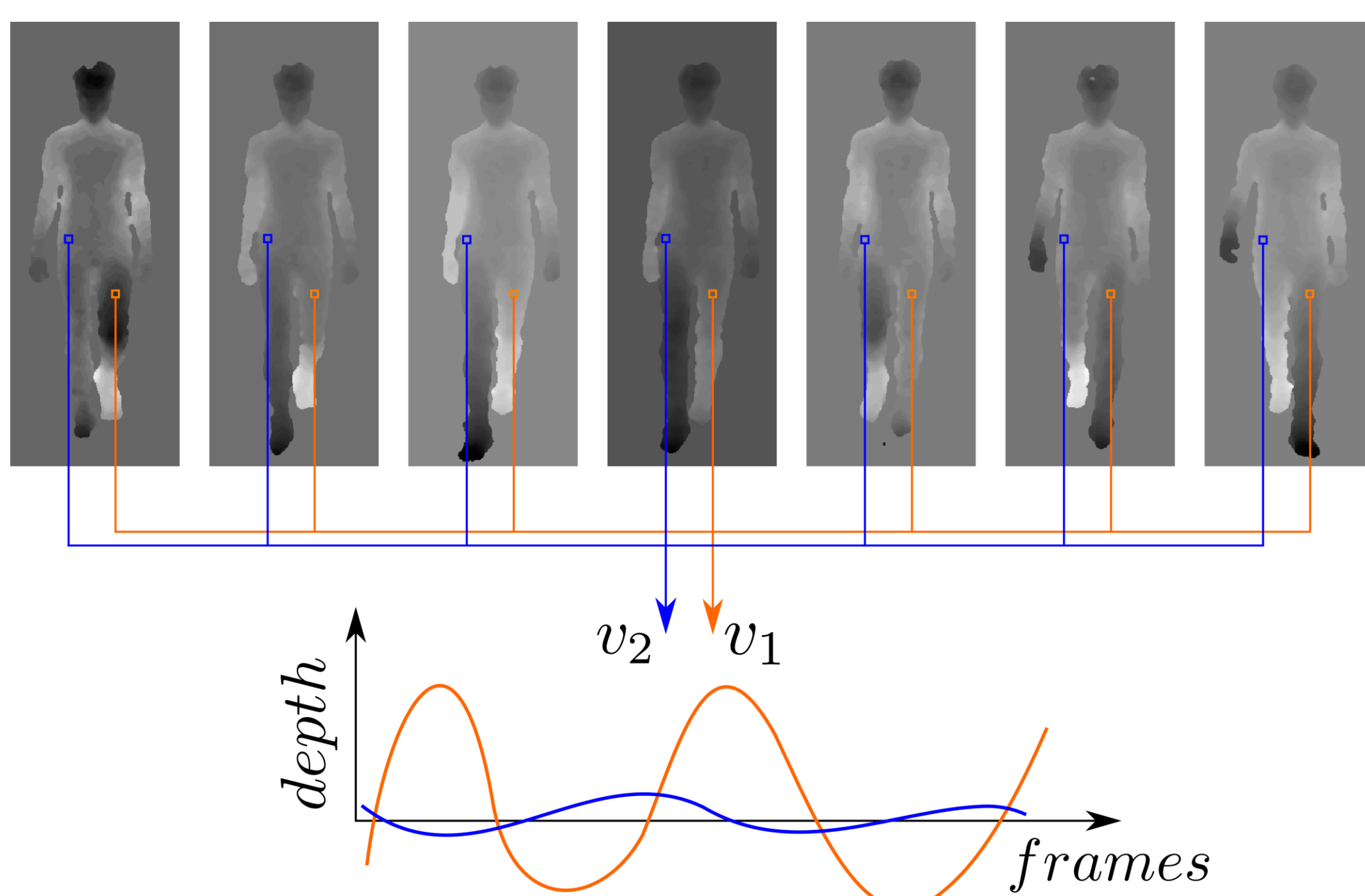


Fig. 1: Setup and pre-processing steps. (a) Original depth map. (b) After clipping. (c) After treadmill removal.

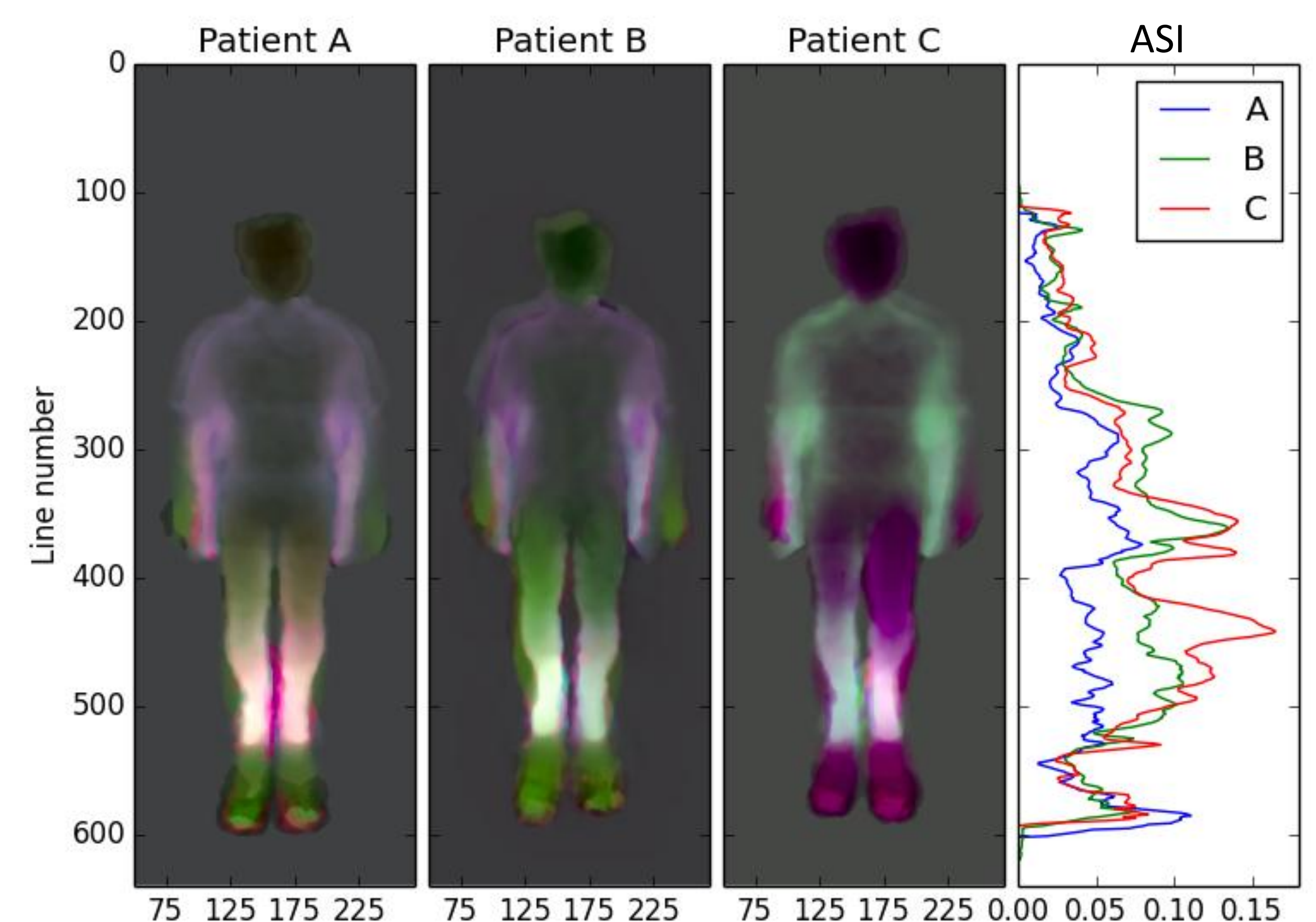
Step 3.1: For each pair of pixels, compute (a)symmetry with time-shift-invariant distance d_{tsi} between their N-dimensional depth signals $s_1(t)$ and $s_2(t)$:

$$d_{tsi}(s_1, s_2) = \min_{\forall \tau} \left\{ \sum_{t=0}^N (s_1(t + \tau) - s_2(t))^2 \right\}$$



Step 3.2: MDS mapping from N-D to the 3-D perceptually uniform color space $L^*a^*b^*$. MDS preserves distances.

➤ **Asymmetry index (ASI):** Mean difference between original $L^*a^*b^*$ map and its mirror image



Experimental Results

Dataset:

Subjects walking on a treadmill, facing a Kinect

- Normal walk (group A)
- 5 cm sole under the left foot (group B)
- 5 cm sole under the right foot (group C)

Results:

- Asymmetries can be easily detected visually
- Statistically discriminative index (ASI)

TABLE I: Average and SD (σ) of the ASI for the 17 patients

	Normal gait	Left LLD	Right LLD
Average	0.045374	0.053549*	0.055936*
σ	0.008080	0.006274	0.009451

*Paired difference t test is statistically significant ($p < 0.01$)

Conclusion

- New gait analysis system with depth maps
- Cheap, markerless, non-invasive, easy to use, suitable for small room and fast diagnosis
- Color map of gait (a)symmetries + discriminative index (ASI)
- Applications: Assessment of pathologies (affecting gait) and pre- and post-operative (e.g. knee or hip) surgeries