



Light Field Segmentation Using a Ray-Based Graph Structure

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Motivation and Problem

- We are interested in **interactive light field segmentation** from a reference view.
- Challenge for **light fields**: the amount of data to process in order to edit **all the views** simultaneously.
- In particular, the running time for **graph-based approaches**, such as graph-cut, increases greatly with the size of the input graph.
- We assume a **depth map** to be known for each view.

Our Method

Building The Graph

- Previous work focuses on representations with **one graph node per ray** [1].
- Observation: **many rays** of the light field mainly describe the **same content**.
- The **redundancy** is captured by **depth estimation**.
- We use a **single node** to represent **several rays** coming from the same scene point (**ray bundles**), according to an estimated measure:

$$\begin{cases} [x_i + (s_i - s_j)D(s_i, t_i, x_i, y_i)] = x_j \\ [x_j + (s_j - s_i)D(s_j, t_j, x_j, y_j)] = x_i \end{cases}$$

- To handle occlusions and errors in the depth map, rays that have an **incoherent depth** measure (**free rays**) are left in a **single node**.
- The **new neighbourhood relationship** are defined using **each view neighbourhood**.

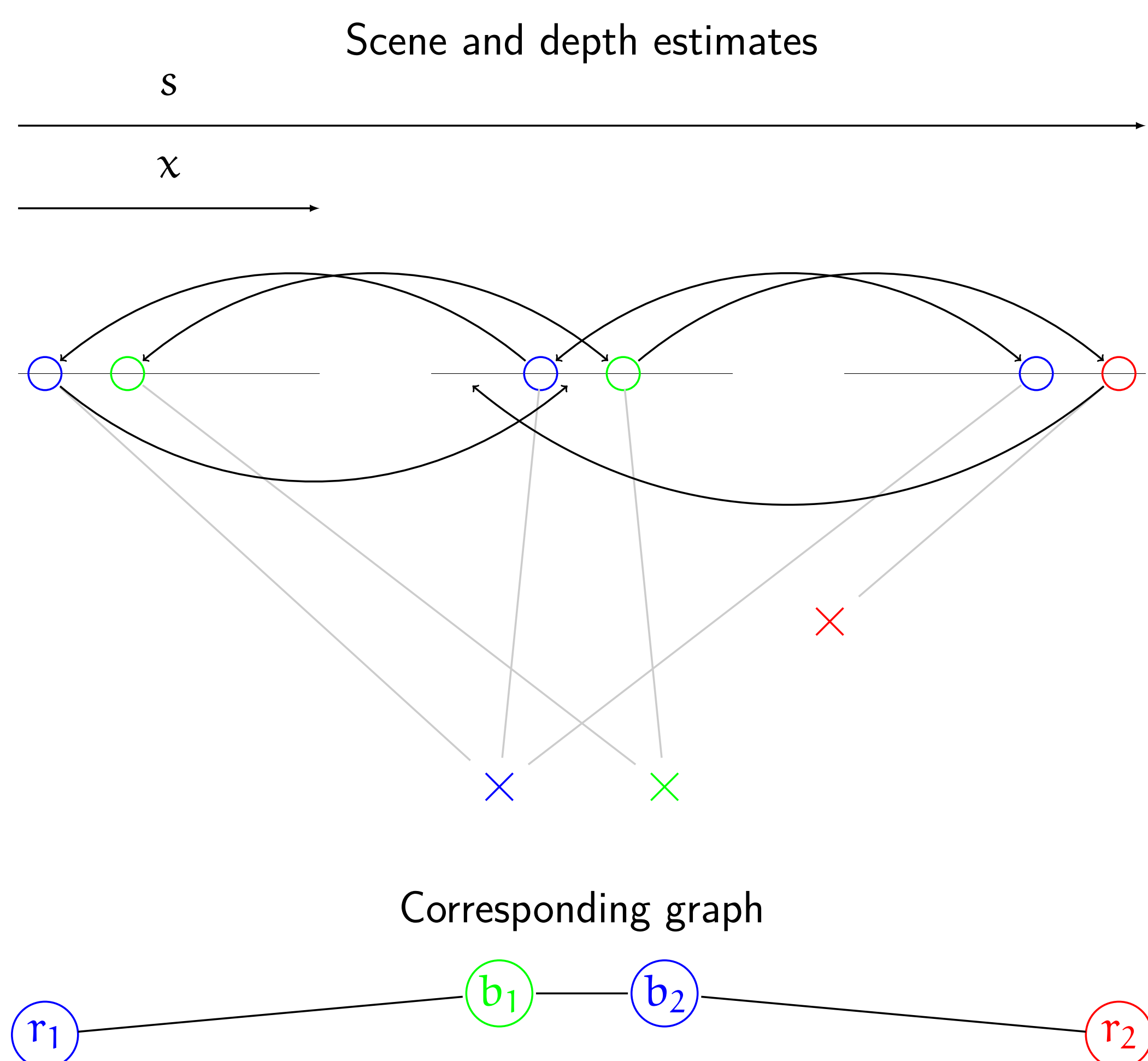


Figure 1: Building the graph structure.

New Energy Terms

- Ray bundle **unary energy term** is defined using Gaussian Mixture Models (GMM) on the **color and the depth** learnt from input scribbles. To compute the **free ray unary**, the **depth component** is **removed** from the GMM:

$$U(b_i) = \begin{cases} -\log(\mathcal{P}(C(b_i), D(b_i)|L(b_i) = \alpha)) & \text{if } \exists r_i \in b_i, S(r_i) = 0 \\ \infty & \text{if } \exists r_i \in b_i, S(r_i) = \alpha \\ 0 & \text{otherwise} \end{cases}$$

- We define the **new neighbourhood relationship** using the **neighbourhood on each view**. Between free rays and ray bundles:

$$P(r_i/b_i, r_j) = \delta_{L(r_i/b_i) \neq L(r_j)} \exp\left(\frac{-\Delta E(C(r_i/b_i), C(r_j))}{\sigma_{Lab}}\right)$$

- Problem: **rays at the object boundaries** tend to be **more connected** to the background node they occlude.

- Solution: **sum the individual view neighbourhood energy term**:

$$P(b_i, b_j) = \delta_{L(b_i) \neq L(b_j)} |b_j \cap \mathcal{N}(b_i)| \exp\left(\frac{-\Delta E(C(b_i), C(b_j))}{\sigma_{Lab}} - \frac{(D(b_i) - D(b_j))^2}{\sigma_D}\right)$$

- We use **alpha-expansion** to minimise the **new energy function**:

$$\varphi_L = \sum_{r_i \in R} U(r_i) + \sum_{b_i \in B} U(b_i) + m \left(\sum_{r_i, r_j} P(r_i, r_j) + \sum_{b_i, r_i} P(b_i, r_i) + \sum_{b_i, b_j} P(b_i, b_j) \right)$$

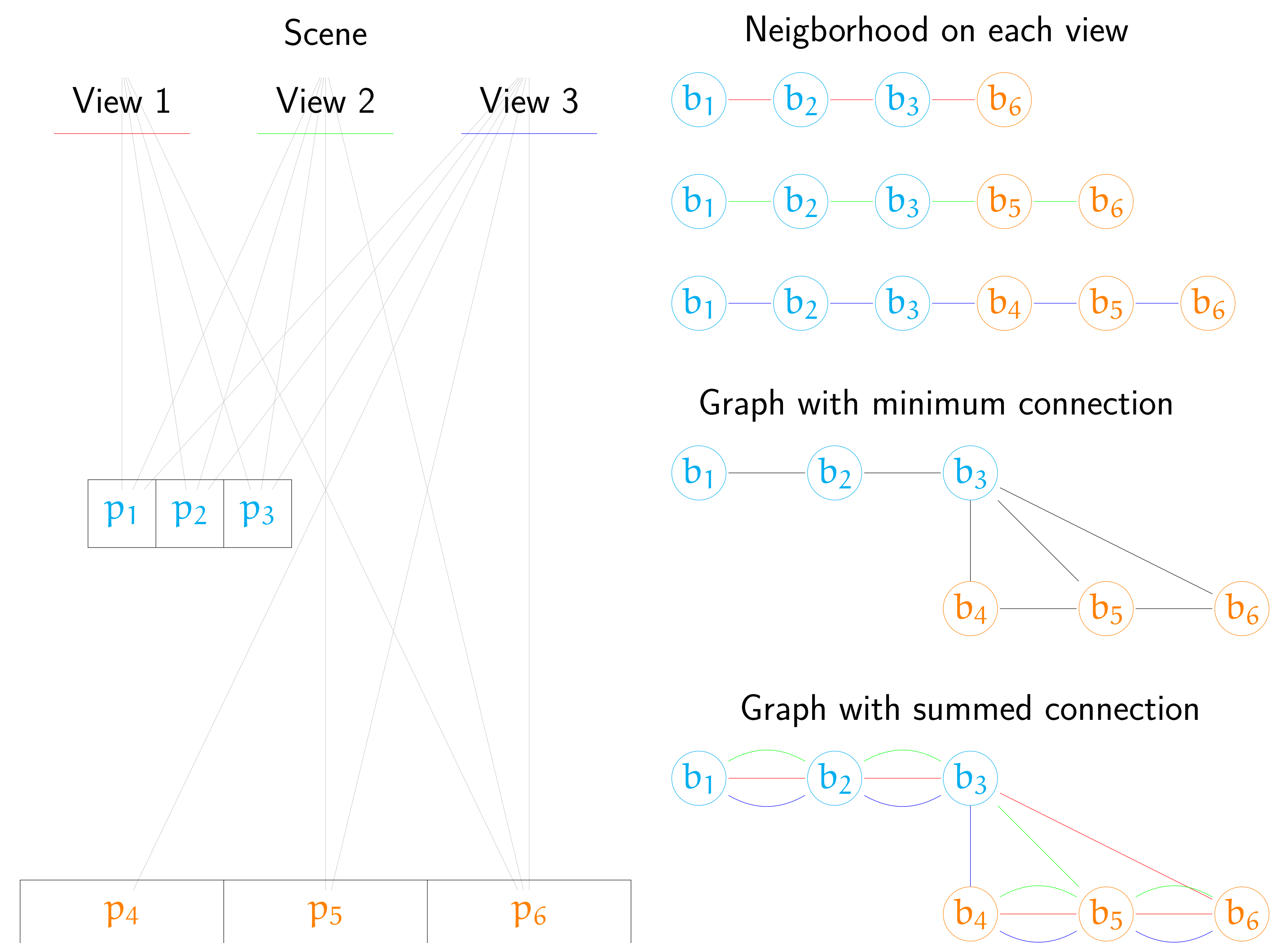


Figure 2: The over-connectivity issue.

Experimental Results

- **Quantitative tests** on synthetic dense light field dataset showed our approach to be **close to the state of the art** [1], with a **lower complexity**. Our approach also shows to be efficient for dense and sparse real light fields from various sources.

Table 1: Segmentation accuracy comparison.

Dataset:	Still life 2	Papillon 2	Horses 2	Budha
Result of [1]:	99.3	99.4	99.3	98.6
Our results:	99.2	99.5	99.1	99.1
Our results w/o depth:	98.91	99.4	95.5	98.8

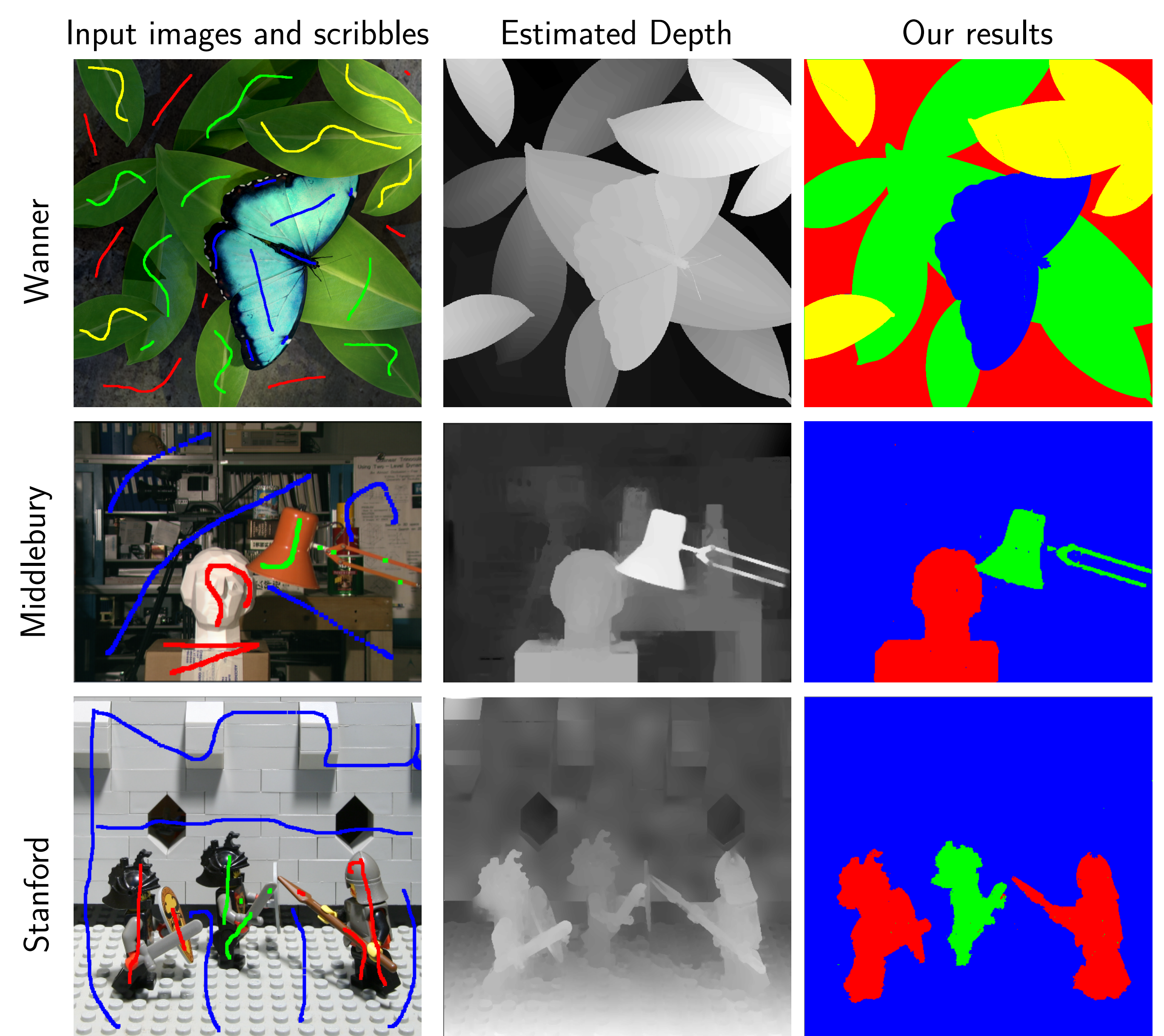


Figure 3: Light-field segmentation results on several datasets.

Summary and Conclusions

- We proposed a **new graph structure** that greatly **reduces the running time** of graph-based algorithm for light fields.
- We demonstrate its efficiency for **interactive light field segmentation**.
- Limitations: as the amount of **depth estimation errors** increases, the number of **nodes rises** and the segmentation **coherence decreases**.

References

- [1] Wanner et al., Globally consistent multi-label assignment on the ray space of 4d light fields, *CVPR 13*