**Problem statement**

**Goal:** 3D interpretation of a line drawing to insert in an existing scene

**Input:** set of photographs of a scene
- Perspective line drawing over one of the photographs

**Output:** a 3D model of the line drawing

**Difficulties:**
- Ill-posed problem (infinite number of shapes can explain the drawing)
- Perspective projection (3D colinear lines are not parallel in the drawing)
- Line drawing not accurate (perspective error)

**Idea:** Exploit the existing scene structure to interpret the drawing.

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**Orientation labelling of facets**

**Energy formulation:**

\[ U(I) = U_{data}(I) + \beta U_{prior}(I) + \gamma U_{complexity}(I) \]

- \( U_{data}(I) \) tests the accuracy of the 3D model generated from \( I \) by measuring its reprojection error on the line drawing:
  \[ U_{data}(I) = \sum_{P \in P} \left\| \Pi(P_{3D}) - P_{2D} \right\|^2 \]

- \( U_{prior}(I) \) penalizes colinearity between adjacent facets:
  \[ U_{prior}(I) = \sum_{\langle I, J \rangle \in \mathcal{E}} \left| \langle l_I, l_J \rangle \right| \]

- \( U_{complexity}(I) \) encourages alignment with the existing scene by penalizing new orientations:
  \[ U_{complexity}(I) = \sum_{\langle I, J \rangle \in \mathcal{E}} \delta_{new}(l_I) \]

**Minimisation using simulated annealing:**

**Algorithm:**

- Compute the dominant orientations \( d_1, \ldots, d_n \)
- Draw a random configuration \( \xi \in \mathcal{X} \)
- Initialize relaxation parameter \( T = T_{init} \)
- Repeat
  - Generate \( I \) by perturbing the label of a random facet
  - Compute the orientations \( d_{new} \) in \( I \)
  - Compute the Metropolis ratio \( R = \frac{e^{-U}(I)}{e^{-U}(\xi)} \)
  - Draw a random value \( \epsilon \in [0, 1] \)
  - If \( \epsilon < R \)
    - Update \( I \)
  - Else
    - Update \( T = T \times 7 \)
    - Update \( I = \xi \)
- Until \( T < T_{min} \)

**3D model inference from labels**

**Estimation of the orientation of facets labeled with \( d_{new} \):**

Edges directions around facet \( i \) are computed from adjacent facets and camera plane.

The new orientation of facet \( i \) is computed from the edge directions.

**Computation of the 3D model knowing the facet labels:**

Express the 3D position of the vertices as combination of edge directions:

\[ P_3 = P_2 + \sum_{e \in \mathcal{E}} \delta_e \alpha_e \mathbf{v}_e \]

\( P_2 \) and \( \alpha_e \) are the unknowns

**Projection error of the 3D model on the line drawing:**

\[ \epsilon = \sum_{P \in P} \left\| \Pi(P_{3D}) - P_{2D} \right\|^2 \]

**Constraints:** each facet forms a closed cycle:

\[ \mathbf{v}_i \in \mathcal{E} \sum_{\mathbf{v}_i \in \mathcal{E}} \epsilon_2 \alpha_e \mathbf{v}_e = 0 \]

**Experiments**

**Results:**

- Ruins (42 edges, 18 facets)
- Desk (69 edges, 25 facets)
- House (93 edges, 38 facets)

**Impact of the complexity term:**

- \( y = 0.005 \)
- \( y = 0.1 \)
- \( y = 0.2 \)

**Stability against new orientations:**

- 3 new orientations
- 6 new orientations
- 11 new orientations
- 7 new orientations (after 15000 iterations)