# Lab 1: Semi Global Stereo Matching with Monocular Disparity Initial Guess

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## Task1: Compute Path Cost

According to (1) and (2) the implementation follows a two-part strategy based on the position of the current pixel within the image.

$$E(p_i, d) = E_{data}(p_i, d) + E_{smooth}(p_i, p_{i-1}) \tag{1}$$

where

$$E_{smooth}(p, q) = \min \begin{cases} E(q, f_q) & \text{if } f_p = f_q \\ E(q, f_q) + c_1 & \text{if } |f_p - f_q| = 1 \\ \min_{0 \le \Delta \le d_{\max}} E(q, \Delta) + c_2 & \text{if } |f_p - f_q| > 1 \end{cases} \tag{2}$$

If the current pixel is at the boundary of the image, special handling is required as there may not be a previous cost to consider. In this case, the initial cost for each disparity is directly obtained from the precomputed cost volume ($E_{data}$).

For pixels not on the boundary, the function computes the path cost considering the previous cost along the path direction. It calculates penalties for disparities, such as small and big penalties based on the difference between neighboring disparities. The minimum penalty cost among these, ($E_{smooth}$), is then added to the cost retrieved from the cost volume ($E_{data}$) for the current pixel and disparity.

The implementation involves nested loops to iterate over disparities and perform penalty calculations. Conditional statements are used to determine the type of penalty to apply based on the difference between neighboring disparities. The final path cost is stored in the *path_cost_* tensor for each disparity value.

## Task2: Aggregation

The initialization process involves setting the values of the path scan variables based on the direction of the current path (*cur_path*). These variables determine the starting and ending points of the scan as well as the direction of the scan over the image pixels.

The switch statements are used to set the values of the path scan variables based on the direction of the current path.

For each component of the direction (horizontal and vertical), a switch statement sets the appropriate values for start, end, and step.

## Task3: Compute Disparity

The algorithm assesses the confidence level of each disparity value, considering predefined criteria. Disparities that meet the confidence threshold are considered reliable and suitable for further processing.

Once disparities with high confidence are identified, they are paired with their respective unscaled disparities from the initial guess.

## Task4: Compute Disparity refinements step

To scale initial guess, we need to find ***h*** and ***k*** according to formula (3).

$$d_{sgm} = h * d_{mono} + k \tag{3}$$

To achieve this objective, we employ formula (4) for the least squares problem concerning a non-homogeneous system, as represented by formulas (5) and (6):

$$Ax = b \tag{4}$$

$$x = (A^T A)^{-1} A^T b \tag{5}$$

where

$$x = [h\, k]^T,\ b = d_{sgm},\ A = [d_{mono,} \bar{1}] \tag{6}$$

A matrix ***A*** of size disparity_pairs.size() x 2 and a vector ***b*** of size disparity_pairs.size() are initialized to store disparity pairs and their corresponding scaled SGM disparities, respectively.

Disparity pairs are iterated over, and their components are assigned to the matrix ***A*** and vector b. The first column of ***A*** represents the unscaled monocular disparities ($d_{mono}$), while the second column represents a constant term 1. The vector ***b*** holds the scaled SGM disparities ($d_{sgm}$).

The least squares problem is solved to find the coefficients ***h*** and ***k*** using the formula (5).

According to (6), once the coefficients ***h*** and *k* are obtained, they are used to scale the monocular disparities. The scaled disparity is calculated using the formula (3).

Where *inv_confidence_* is greater than predefined threshold, the scaled disparities are then assigned to the disparity map (*disp_*) to replace or refine the low-confidence SGM disparities.

## Results

Without refinements step (task 4):

| Data Item | Aloe | Cones | Plastic | Rock1 |
|---|---|---|---|---|
| **MSE** | 140.685 | 305.591 | 831.028 | 391.349 |

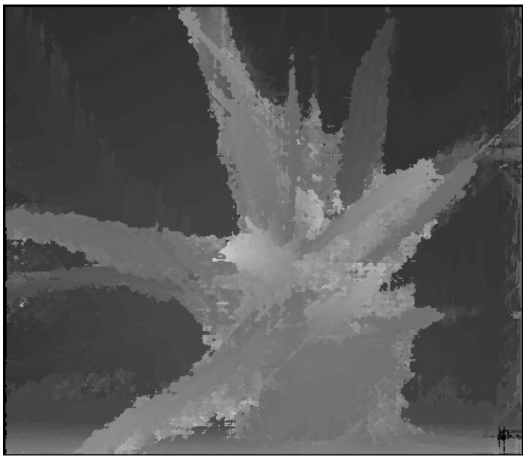

*Figure 1: Aloe*

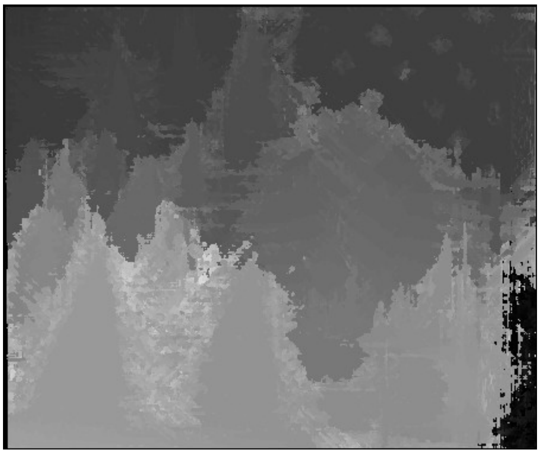

*Figure 2: Cones*

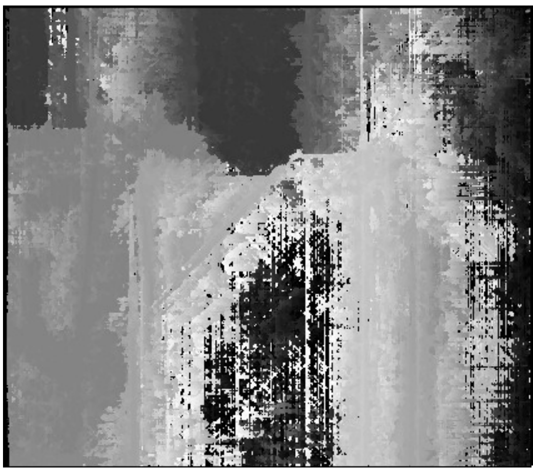

*Figure 3: Plastic*

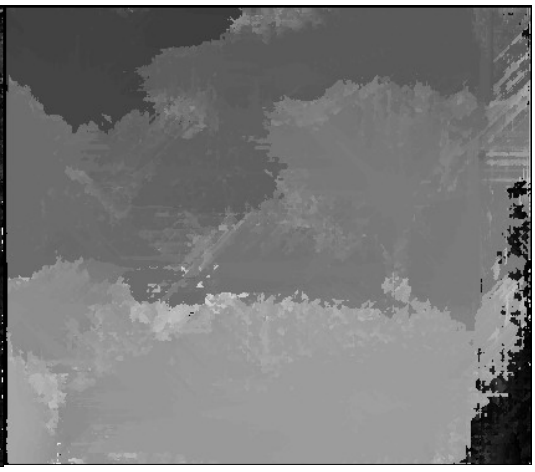

*Figure 4: Rock1*

With refinements step (task 4):

| Data Item | Aloe | Cones | Plastic | Rock1 |
|---|---|---|---|---|
| **MSE** | 67.837 | 56.981 | 124.203 | 56.449 |

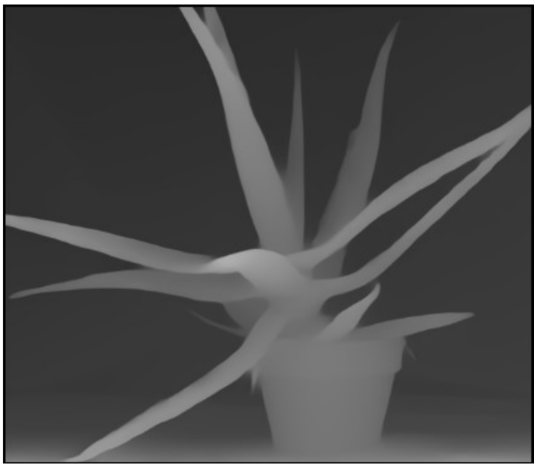

*Figure 5: Aloe*

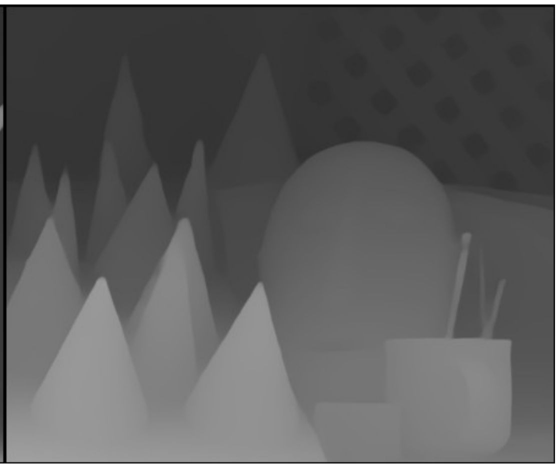

*Figure 6: Cones*

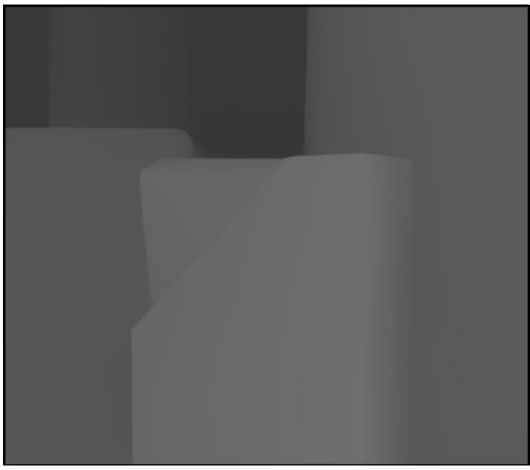

*Figure 7: Plastic*

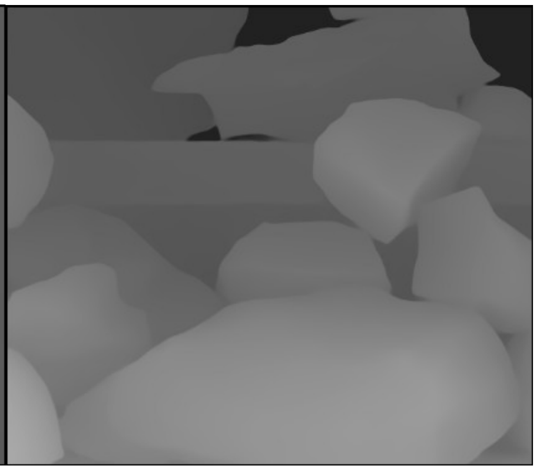

*Figure 8: Rocks1*