CIS 580 HW4

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3. The flow plots for threshold = 1,10,30 are as follows:

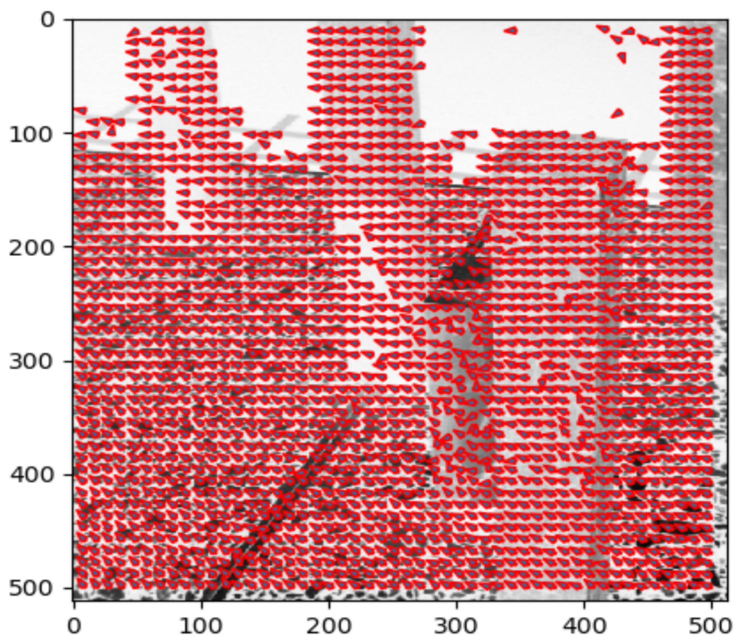

Figure 1: Optical flow with thresmin = 1

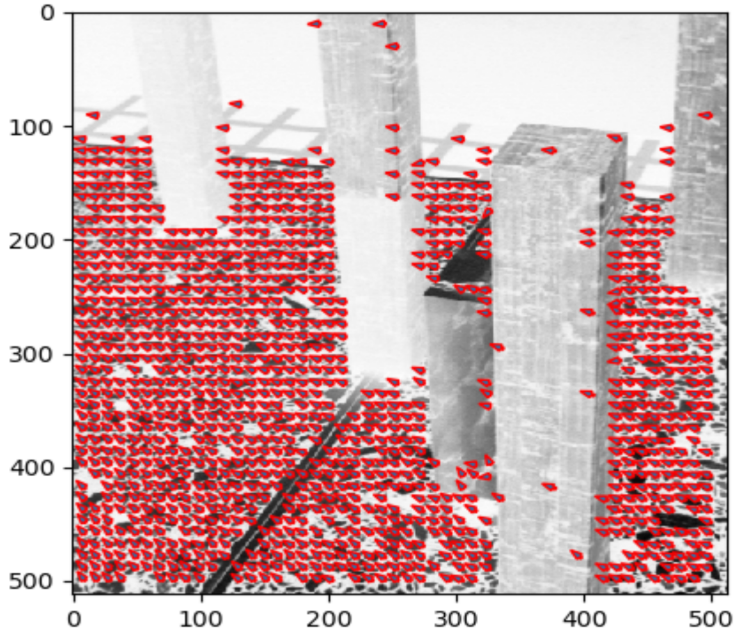

Figure 2: Optical flow with thresmin = 10

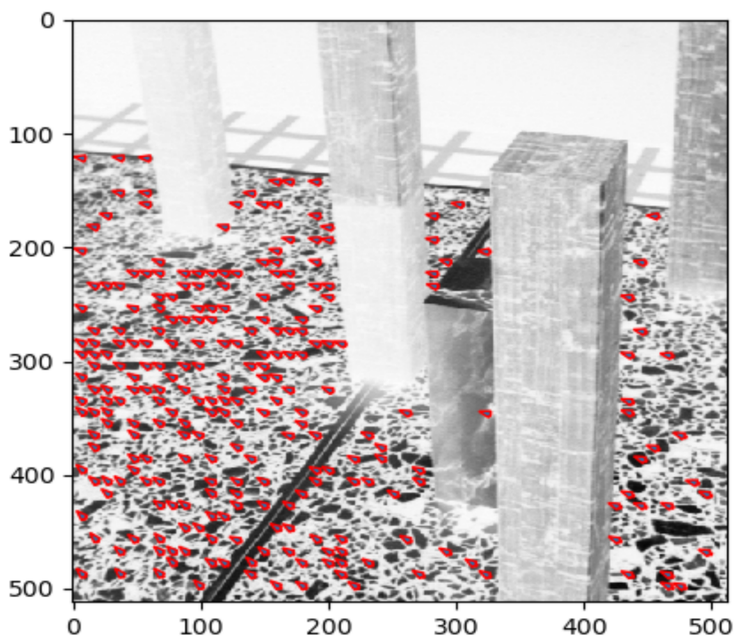

Figure 3: Optical flow with thresmin = 30

4. For the case of pure transnational motion with motion along the Z-direction as well, the epipole does not lie at infinity. The optical flow is radial and points towards the epipole. This can also be seen from the optical flow plot where the vectors point towards the epipole.

   As the value of thresmin is increased, the epipole moves towards the origin because only the best of inliers remain. These inliers mostly lie on the textured surface. This is expected as the textured surface is expected to create the strongest optical flow in the direction of motion. This is because in the optical flow equation, the gradient matrix has the a large condition number for textured surfaces and low condition number for surfaces that have less or no texture.

   Moreover, the places like the poles spanning the entire image create aperture problem which causes the optical flow at that point to be erroneous.

   As the value of thersmin is increased, only the best optical flow vectors remain which give a better estimate of the correct epipole location. The plot of the epipole and inliers is as follows:

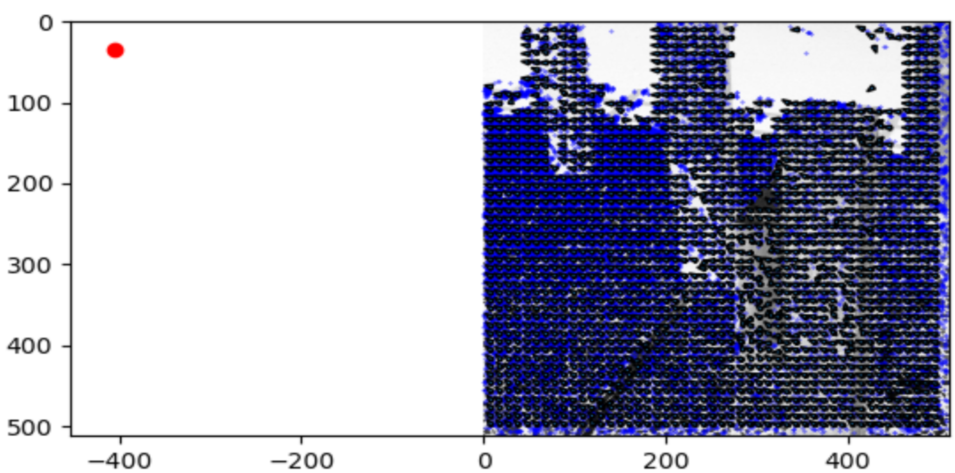

Figure 4: Epipole and inliers with thresmin = 1

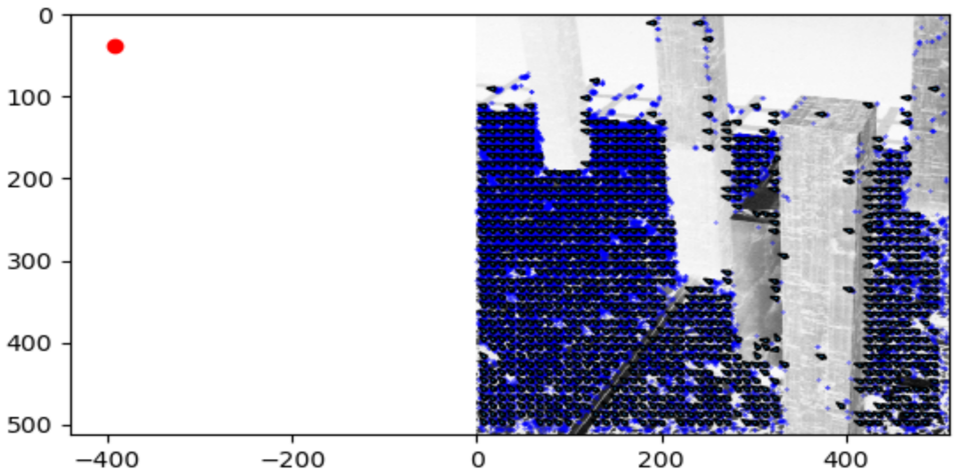

Figure 5: Epipole and inliers with thresmin = 10

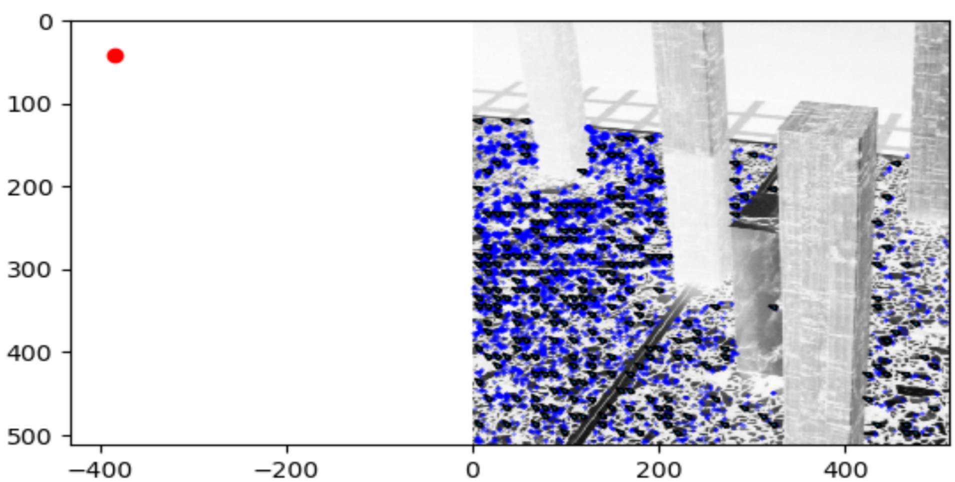

Figure 6: Epipole and inliers with thresmin = 30

5. When calculating the depth plots, I am using the optical flow vectors, the pixel coordinates, and the epipole location. For areas that are not textured enough, the value of confidence barely surpasses the thresmin value of 10. Hence, at these location the optical flow vector is not accurate and causes the resultant calculation of the depth at these locations to be erroneous.

   This can be seen in the depth plot of thresmin=10 where the depth around the pole in the middle is erroneous. The corresponding optical flow plot also shows that the optical flow patterns at these location do not match its surroundings. Moreover, for lesser confidence values, the depth of measurement of the planar textured surface is erronous. This can be seen from the Figure 7 in which the depth barely increases as we move away on the textured surface due to bad inliers. On the other hand, in Figure 9, the effect of depth can be clearly seen on the textured surface as this contains good inliers.

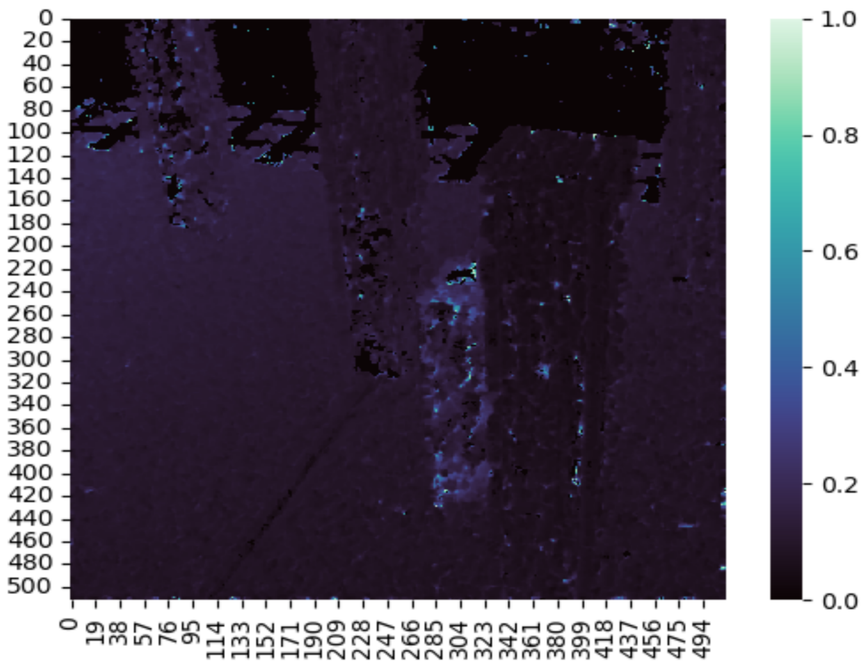

Figure 7: Depth map with thresmin = 1

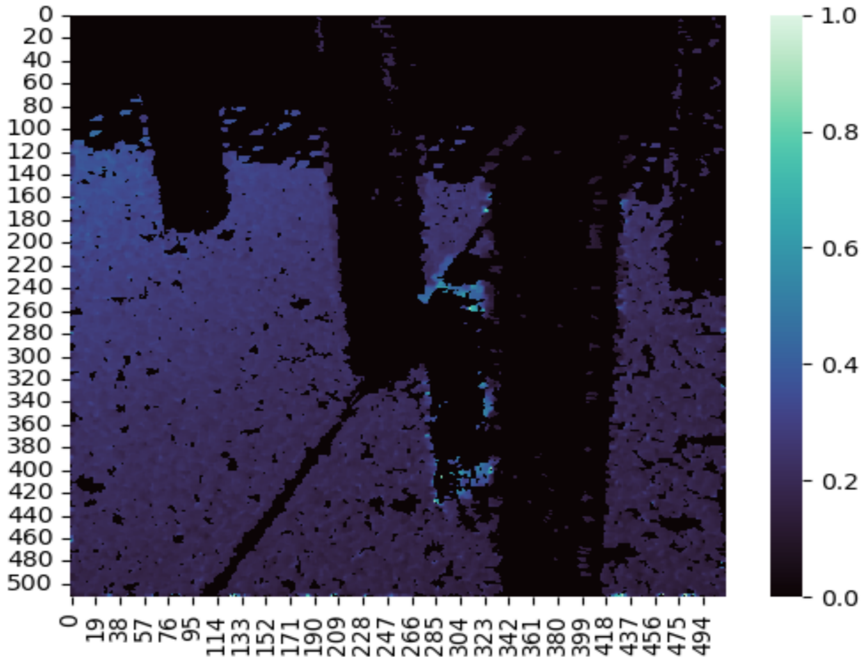

Figure 8: Depth map with thresmin = 10

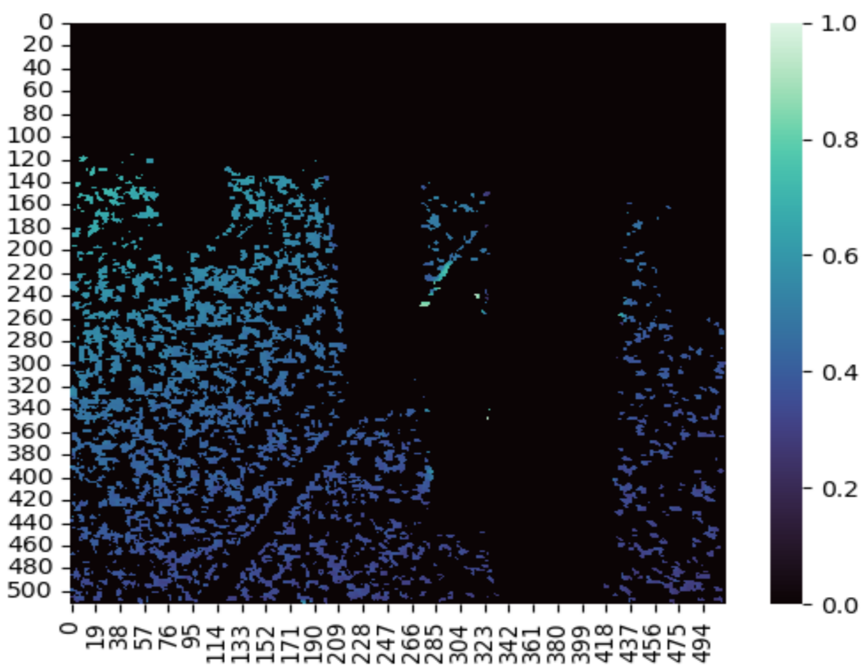

Figure 9: Depth map with thresmin = 30

6. Equation of the plane is given by $N^T(X, Y, Z) = 1$ and I consider a point P on this plane

   From the projection equation the corresponding point on the image plane is $p = \frac{f*P}{Z}$. Substituting this back in the plane equation, I get

   $N^T.P = 1 = N^T.\frac{p*Z}{f}$

   Solving for Z, I get

   $Z = \frac{f}{N_x*x+N_y*y+N_z*f}$

   The equation of optical flow is given as the sum of translational and rotational components as follows:

   $\dot{x} = \frac{T_z*x-T_x*f}{Z} - \omega_y * f + \omega_z * y + \frac{\omega_x*xy}{f} - \frac{\omega_y*x^2}{f}$

   $\dot{y} = \frac{T_z*y-T_y*f}{Z} - \omega_x * f - \omega_z * x - \frac{\omega_y*xy}{f} - \frac{\omega_x*y^2}{f}$

   Now substituting the value of depth in these equations and solving, I get the equations as follows:

   $\dot{x} = \frac{a1*x^2+a2*xy+a3*fx+a4*fy+a5*f^2}{f}$
   $\dot{y} = \frac{a1*xy+a2*y^2+a6*fy+a7*fx+a8*f^2}{f}$

   Here, $a1 = -\omega_y + T_z * N_x, a2 = \omega_x + T_z * N_y, a3 = T_z * N_z - T_x * N_x, a4 = \omega_z - T_x * N_y, a5 = -\omega_y - T_x * N_z, a6 = T_z * N_z - T_y * N_y, a7 = -\omega_z - T_y * N_x, a8 = \omega_x - T_y * N_z$

   From the equations above, it is apparent that I can write $(\dot{x}, \dot{y})$ as function of eight parameters which depend on T, ω, and N and that it is quadratic with respect to (x, y).

   For finding these 8 components, I use the window given to us to get the pixel coordinates and the value of flow. For the given window of 200x200, I use the above derived equations and write the entire system as a system of linear equations of the following form.

$$\begin{pmatrix} x^2 & xy & x & y & 1 & 0 & 0 & 0 \\ xy & y^2 & 0 & 0 & 0 & y & x & 1 \end{pmatrix} * \begin{pmatrix} a1 \\ a2 \\ a3 \\ a4 \\ a5 \\ a6 \\ a7 \\ a8 \end{pmatrix} = \begin{pmatrix} \dot{x} \\ \dot{y} \end{pmatrix}$$

Solving for this system gives me the value of the 8 required coefficients.