

Mensuration Algorithm

Assumption: The vanishing line is given

Problem: Given the reference length $\|MN\|=1$ in multiple frames as $m_i n_i$ and a probe line segment ST also in multiple frames as $s_j t_j$, measure $\|ST\|$.

Fact: If for all frame i , M_i are same, then N_i are distributed in a unit circle centering at M_i . Furthermore, if $S_j=M_i$, then T_j and N_i are on two concentric circles respectively.

Solution

Arbitrary select point o and parallel move $m_i n_i$ to op_i , $s_j t_j$ to oq_j . World points P_i are on a circle C_p and Q_j on a concentric circle C_q

$$C_p = C_0 - r_p^2 \quad C_q = C_0 - r_q^2$$

C_0 is the circle centering at O with zero radius.

$$H^{-1} \begin{pmatrix} \times & \times & \times \\ \times & \times & \times \\ L(1) & L(2) & L(3) \end{pmatrix} \quad L \text{ is the vanishing line}$$

p_i and q_j are on two concentric ellipses centering at o

$$E_{p,q} = E_0 - r_{p,q}^2 L \quad L = H^{-T} \text{diag}(0,0,1)H^{-1}$$

$$E_0 : a_0(x - x_0)^2 + b_0(x - x_0)(y - y_0) + c_0(y - y_0)^2 = 0$$

Finally $a_0(x_p - x_0)^2 + b_0(x_p - x_0)(y_p - y_0) + c_0(y_p - y_0)^2 - \alpha_p(Lp_i)^2 = 0$

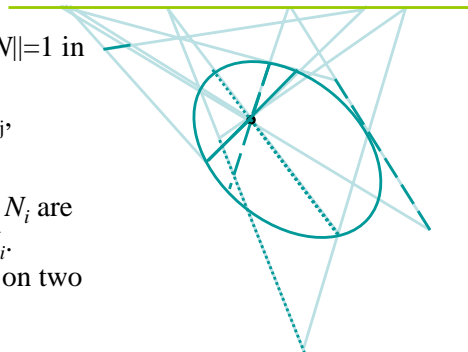
$$a_0(x_q - x_0)^2 + b_0(x_q - x_0)(y_q - y_0) + c_0(y_q - y_0)^2 - \alpha_q(Lq_j)^2 = 0$$

$(a_0 \ b_0 \ c_0 \ \alpha_p \ \alpha_q)^T$ can be solved by Singular Value Decomposition (SVD)

The ratio between the two radii

$$r = \sqrt{\alpha_p / \alpha_q}$$

Example



Wheelbase Detection



Key: Use the intensity difference between the wheel covers and the tires

the Vanishing Line Estimation

Represent the vanishing line as $(-\sin \phi \sin \theta, \cos \phi \sin \theta, -f \cos \theta)$

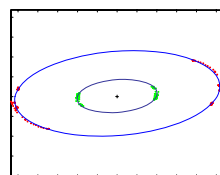
θ : elevation angle ϕ : rotation angle f : focal length

Minimize the variance of $\cos^2(\theta) = \frac{\cos^2 \phi - r^2 \sin^2 \phi - 2c_\alpha \cos \phi \sin \phi + c_\alpha^2 \sin \phi}{\sin^2 \phi - r^2 \cos^2 \phi + c_\alpha \cos \phi \sin \phi + c_\alpha^2 \cos \phi}$

$$r = \left| \frac{\delta x_2 \delta y_1 - \delta x_1 \delta y_2}{\delta x_1^2 - \delta x_2^2} \right| \quad c_\alpha = \frac{\delta x_1 \delta y_1 - \delta x_2 \delta y_2}{\delta y_1^2 - \delta y_2^2} \quad \delta x_i = x_{i1} - x_{i2} \quad \delta y_i = y_{i1} - y_{i2}$$

Objective & Contribution

An automated system for wheelbase measurement of moving vehicles



Mensuration Result

