**Formulas and Derivation for coaxial camera**

Projection Equations

(1)

(2)

where X, Y, and Z are coordinates in the scene and x and y are image coordinates.

Differentiate to get optical flow (also can be done geometrically page 110):

(3)

(4)

(4)

(5)

(6)

(7)

(8)

(9)

(10)

(11)

(12)

(13)

(14)

(15)

For y to end an the axis, rotate through the angle:

(16)

(17)

(18)

substitute:

(19)

(20)

For the coaxial camera this becomes:

(21)

(22)

or

(23)

where

(23)

We find h using an energy optimization with the following energy equation along a radial line:

(21)

(22) (23)

Once we have the estimate for h, we can compute W from equation (9) or (10) as follows:

(21)

(22)

QED