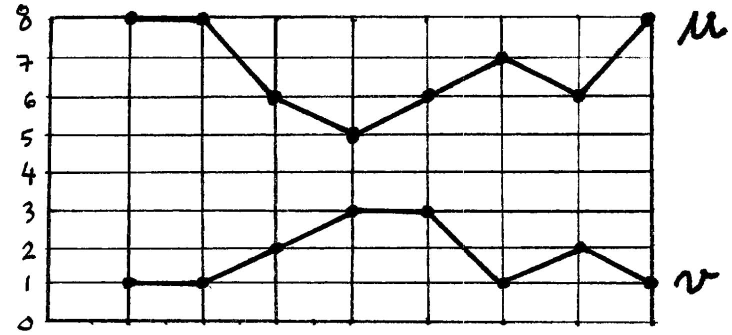
# GRAD 590D Exam 2

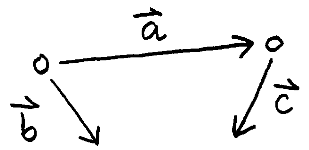
______________________ Name

12 Dec 2007, 2 Hours, 1 Page Notes Allowed

— SHOW YOUR WORK —

1. 


$u$ and $v$ are two intensity profiles from a digital image. What is the cross correlation coefficient between these two signals?

2. 


Three vectors are given as,

$\vec{a} = [7, 6, -1]$

$\vec{b} = [2, 4/3, -6]$

$\vec{c} = [-2, -2, -4]$

Show whether these three vectors are <u>coplanar</u>.

3. A CCD array is specified as "½ inch." Recall diagonal of CCD is ≈ 70% of given inch size. Number of Rows in the array is 2200, number of columns is 2933. The focal length for an image is given in the header as 12 mm. What is the focal length in <u>pixels</u>?

4. The following information describes the parameters of a photo acquisition mission:

image size: 23 cm (conventional aerial photo)

$f$: 152.4 mm

$H$ (above terrain): 800 m

aircraft speed: 240 km/hr

forward overlap: 80%

What is the time interval between exposures?

5. Kinematic GPS in an aircraft records an antenna position every second:

$$\begin{bmatrix} X \text{ (m)} \\ Y \text{ (m)} \\ Z \text{ (m)} \\ \text{time h:m:s} \end{bmatrix} : \begin{bmatrix} 10\,000 \\ 5\,000 \\ 1\,000 \\ 10{:}00{:}00 \end{bmatrix}, \begin{bmatrix} 10\,200 \\ 5\,100 \\ 1\,000 \\ 10{:}00{:}01 \end{bmatrix}, \begin{bmatrix} 10\,400 \\ 5\,200 \\ 1\,005 \\ 10{:}00{:}02 \end{bmatrix}, \begin{bmatrix} 10\,605 \\ 5\,302 \\ 998 \\ 10{:}00{:}03 \end{bmatrix}, \ldots$$

An image is captured at time 10:00:02.36. What are the antenna coordinates at that time?

6. (a) A relatively oriented stereo model should be free of ____________________.

(b) The <u>plane</u> formed by the <u>base vector</u> between two exposure stations, and <u>two</u> <u>object space vectors</u> corresponding to conjugate points on the two photographs is called ____________________.

(c) The apparent change in position of an object due to a change in the view location is called ____________.

(d) The B/H ratio for a stereo model is usually greater than the b/h of the human visual system. This difference causes ____________________ when viewing the stereo model.

(e) We convert between space domain and frequency domain using the ____________________.

(f) How many control point coordinate components are needed to minimally constrain a stereo model to the reference coordinate system? ____________.

(g) The data structure for irregularly sampled terrain points is called ________________.

# Grad 590D Exam 2 Solution
12 December 2007

1.

| $u$ | $u-\bar{u}$ | $v$ | $v-\bar{v}$ | $(u-\bar{u})(v-\bar{v})$ | (cumulative) $\sum(u-\bar{u})(v-\bar{v})$ |
|---|---|---|---|---|---|
| 8 | 1.25 | 1 | -.75 | -.9375 | -.9375 |
| 8 | 1.25 | 1 | -.75 | -.9375 | -1.875 |
| 6 | -.75 | 2 | .25 | -.1875 | -2.0625 |
| 5 | -1.75 | 3 | 1.25 | -2.1875 | -4.25 |
| 6 | -.75 | 3 | 1.25 | -.9375 | -5.1875 |
| 7 | .25 | 1 | -.75 | -.1875 | -5.375 |
| 6 | -.75 | 2 | .25 | -.1875 | -5.5625 |
| 8 | 1.25 | 1 | -.75 | -.9375 | -6.5 |

$\bar{u} = 6.75$ $\quad \sum(u-\bar{u})^2 = 9.5$ $\quad \bar{v} = 1.75$ $\quad \sum(v-\bar{v})^2 = 5.5$

$$\text{sample correlation coefficient} = \frac{\sum(u-\bar{u})(v-\bar{v})}{\left[\sum(u-\bar{u})^2 \sum(v-\bar{v})^2\right]^{1/2}} = \frac{-6.5}{\sqrt{9.5 \cdot 5.5}} = -0.899$$

This makes sense, since the curves are nearly "opposite"

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2. 3 vectors: $(7,6,-1)$, $(2, 4/3, -6)$, $(-2,-2,-4)$ $\quad \vec{a}, \vec{b}, \vec{c}$

are coplanar if $\vec{a} \cdot (\vec{b} \times \vec{c}) = 0$, or $\begin{vmatrix} 7 & 6 & -1 \\ 2 & 4/3 & -6 \\ -2 & -2 & -4 \end{vmatrix} = 0$ (determinant)

expand determinant:

$$7\left(-\tfrac{4}{3}\cdot 4 - 2\cdot 6\right) - 6(-2\cdot 4 - 2\cdot 6) - 1\left(-2\cdot 2 + 2\cdot \tfrac{4}{3}\right) = ?$$

$$7\left(-\tfrac{16}{3} - 12\right) - 6(-8-12) - \left(-4 + \tfrac{8}{3}\right) =$$

$$7\left(-\tfrac{52}{3}\right) - 6(-20) - \left(-\tfrac{4}{3}\right) = -\frac{364}{3} + 120 + \tfrac{4}{3} =$$

$$-121\tfrac{1}{3} + 120 + \tfrac{4}{3} = \underline{\underline{0}} \Rightarrow \text{3 vectors } \underline{\text{are}}\ \underline{\text{coplanar}}$$

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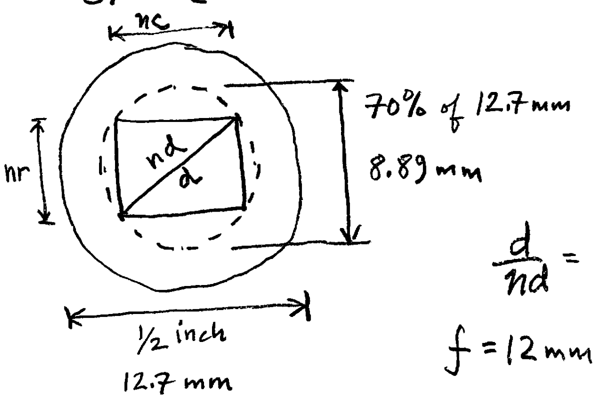
3. "½ inch" CCD



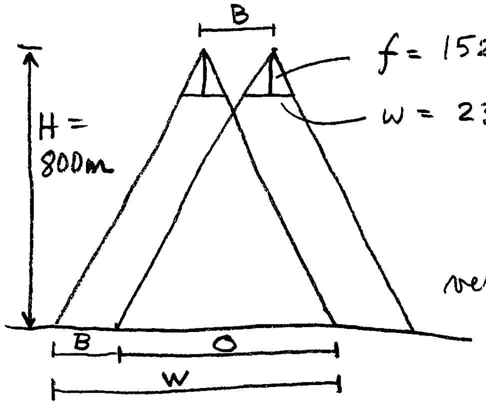

$d = 8.89$ mm
$n_r = 2200$ pix
$n_c = 2933$ pix
$n_d = \sqrt{2200^2 + 2933^2}$
$n_d = 3666.4$ pix

note: use conversion factor 1 inch = 25.4 mm

$$\frac{d}{n_d} = \frac{8.89 \text{ mm}}{3666.4 \text{ pix}} = 0.0024247 \text{ mm/pix}$$

$$f = 12\text{ mm}, \quad f = \frac{12 \text{ mm}}{.0024247 \text{ mm/pix}} = \underline{4949 \text{ pixels}}$$

4.




scale = $\frac{.1524}{800}$ = 1 : 5249.34

W = 0.23 × 5249.34 = 1207.35 m

O = 0.8 × 1207.35 = 965.88 m

B = 0.2 × 1207.35 = 241.47 m

velocity = 240 km/hr. = 240000 meters/hr.

$d = vt$, $t = d/v$, $t = \frac{B}{vel.} = \frac{241.47 \text{ m}}{240000 \text{ m/hr.}}$

t = .001006125 hr, = .0603675 min, = **3.622 sec**

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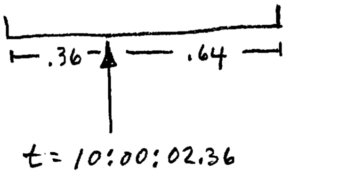
5.

| | | |
|---|---|---|
| X | 10400 | 10605 |
| Y | 5200 | 5302 |
| Z | 1005 | 998 |
| t | 10:00:02 | 10:00:03 |




linear interpolation by weighting

X: .64 · 10400 + .36 · 10605 = 10473.80

Y: .64 · 5200 + .36 · 5302 = 5236.72

Z: .64 · 1005 + .36 · 998 = 1002.48

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(a) y-parallax

(b) epipolar plane

(c) parallax

(d) vertical exaggeration

(e) Fourier transform

(f) 7 : ($\omega$, $\varphi$, $\kappa$, scale, $T_x$, $T_y$, $T_z$)

(g) TIN : Triangulated Irregular Network