A photogrammetry system

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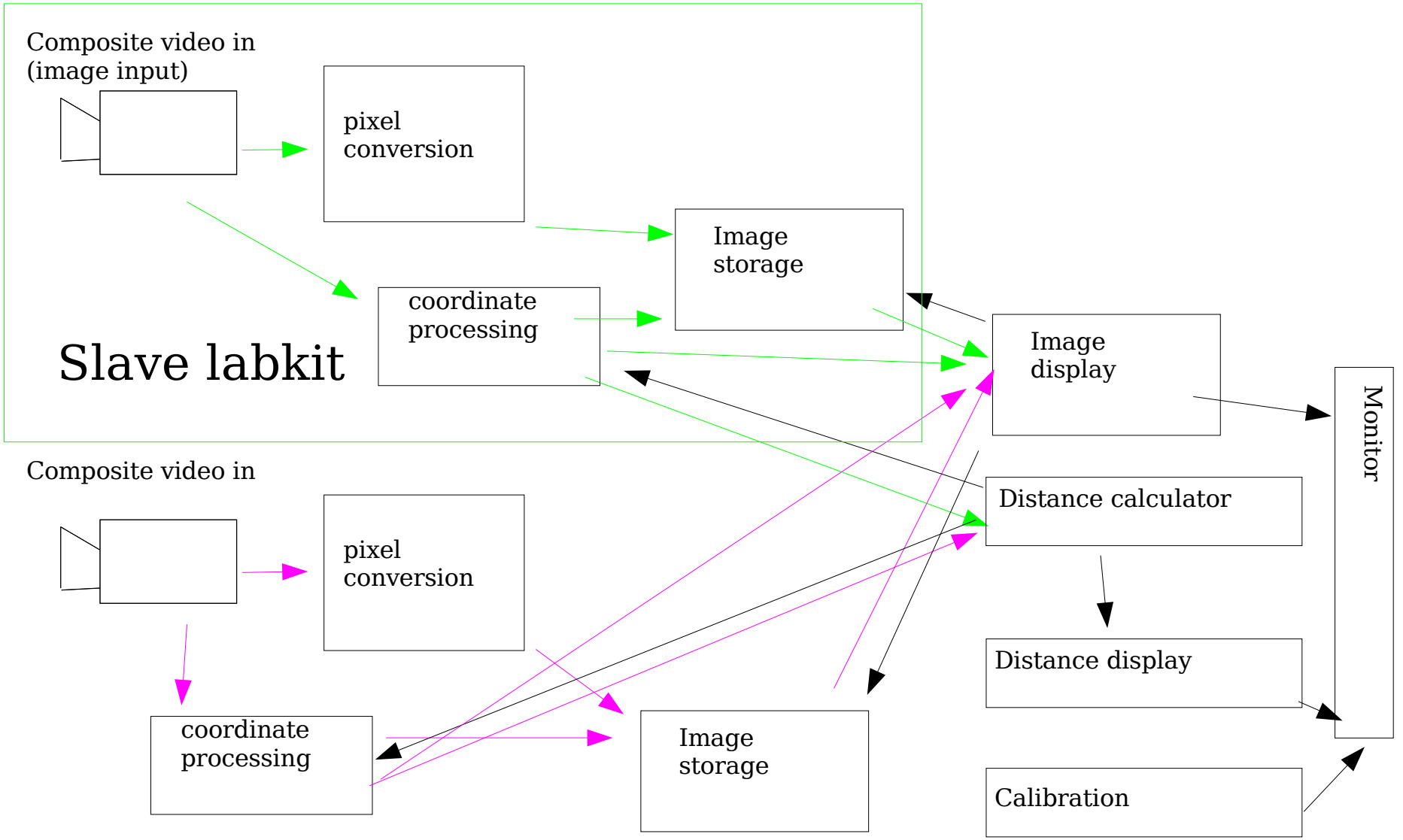
Objective: determine the distance to an object from two photographs of the same object

parts that a working system will have:

- Image input (x2)
- pixel conversion from YUV to RGB (x2)
- coordinate processing (x2)
- Image storage (x2)
- Distance calculation
- Display of distance
- Display of images
- Calibration

Higher level overview



implementation: input

Will use Javier's module for system inputs:

- h sync
- v sync
- 24-bit YUV

implementation : pixel conversion

Will produce 24 b RGB data from 24 b YUV data
Multiply YUV data by constants to get RGB data:

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.147 & -0.289 & 0.436 \\ 0.615 & -0.515 & -0.100 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

(from wikipedia.org)

Lower level : coordinate processing

Inputs:
- h sync
- v sync
- field
- 8 bit luminance (Y)
- used (from distance calculator)

Outputs:
- x coordinate
- y coordinate
- averaged x coordinate
- averaged y coordinate
- new

Implementation:
- x coordinate counts with clock (every other cycle)
- x coordinate resets on h sync
- y coordinate counts h sync pulses
- Y coordinate resets on v sync
- coordinate processing unit stores x and y values for pixels exceeding a threshold luminance, and keeps track of how many pixels exceed the threshold
- on a v sync, the coordinate processing unit calculates the centroid of the x and y values
- new pulses high when a new averaged coordinate is calculated
- Used pulses high when the new averaged coordinate is used by the distance calculator

Lower level : coordinate processing : centroid calculation

- Store the **n** x and y coordinate values that exceed luminance threshold in a frame
- During v sync pulse, calculate average x and y values:
  1) Add first n x and y values from memory
  2) Divide x and y sums by **n**
- Storing 720 x 520 pixels 30 times per second requires a bit rate of 11 Mb/s
- storage required (worst case) is 720 x 520 x 20 bits = 7 Mb (requires SIMM)

Lower level : image storage

Inputs:
- 10 bit x coord (from coord proc)
- 10 bit y coord (from coord proc)
- 24 bit RGB data (from converter)
- 10 bit x coord (from image display)
- 10 bit y coord (from image display)
- pixel request (from image display)

Output:
- 24 bit RGB data (to image display)

- Storage unit uses x and y coordinate values to address 24 bit pixel RGB data
- size requirement is 2 x 520 x 720 x 24 b = 18 Mb
- bitrate is 2 x 520 x 720 x 30 fps = 22 Mb/s
- will using SIMMs on labkit

Lower level: distance calculator

Inputs:
10 bit x av pixel for Image1
10 bit y av pixel for Image1
10 bit x av pixel for Image2
10 bit y av pixel for Image2

outputs:

X [10 bit position]
Y [10 bit position]
Z [10 bit position]

Distance is calculated from average x and y pixel values for two images and a matrix defining an affine transform
Distance calculation requires knowledge of 12 constants defining transformation from image to 3D space
constants are determined by using calibration feature to

- get pixel locations in image
- using Matlab script to determine coefficients
- coding coefficients into verilog

Lower level: distance calculator: input timing

- On reset, distance calculator checks the interval between the two camera's done signals
- the shorter interval is used to pick the first camera
- the 3D position from the second camera's previous 'done' signal is stored
- when a new position becomes available from the second camera, a new 3D position is calculated
- the two 3D position values are averaged weighted according to how much time passed between the two frames from the second camera

Lower level: calibration module

Calibration mode shows the position of a user-selected point in the image coordinate system

inputs are:
    switch and direction buttons
outputs are:
    10 bit cursor y (to monitor)
    10 bit cursor x (to monitor)
    show calibration flag

If calibration mode is on (controlled by user with switch):
- a + is displayed on the image along with the +'s coordinates in the image coordinate system
- the position of the + is displayed below the image
- the position of the + is controlled with the arrow keys

Image display : lower level

Image display is a wrapper that accesses the stored images and outputs the rgb value for a given pixel
input:
    11 bit x position (from monitor)
    10 bit y position (from monitor)
    24 bit pixel value (from image storage) (x2)
output:
    10 bit x position (to image storage) (x2)
    10 bit y position (to image storage) (x2)
    pixel request (x2)

Position display: lower level
input:
    10 bit {X,Y,Z} data
    11 bit x position
    10 bit y position
output:
 24 bit pixel that uses text display module

Monitor: lower level

Inputs:

- 24 bit RGB pixel for image display (x2)
- 24 bit RGB pixel for text display
- 10 bit x value for calibration pixel
- 10 bit y value for calibration pixel
- show-calibration flag

Outputs:

- 24 bit RGB signal to monitor
- h sync
- v sync