Computer Vision Electronic Lap Timing Software

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Objectives

Create a vision based alternative to traditional Induction Loop based Lap Timing Systems that is easy to deploy, fast and inexpensive.

Overview and Challenges

The power of modern computers has made available the possibility of real time high quality video processing. By using Finder Patterns (common in QR tags) my project will extract a number from a video frame before using OCR techniques to identify it. Challenges include: requirement for close to real time results, repeatable accuracy in dynamic outdoor environments and selecting appropriate compatible hardware to capture multiple fast moving targets.

Program Control Flow

In order to achieve the necessary speed my program is pipelined and heavily threaded. Each blue box bellow is a threaded process and each green box is a storage buffer between the threads. Arrows show pipeline data flow.

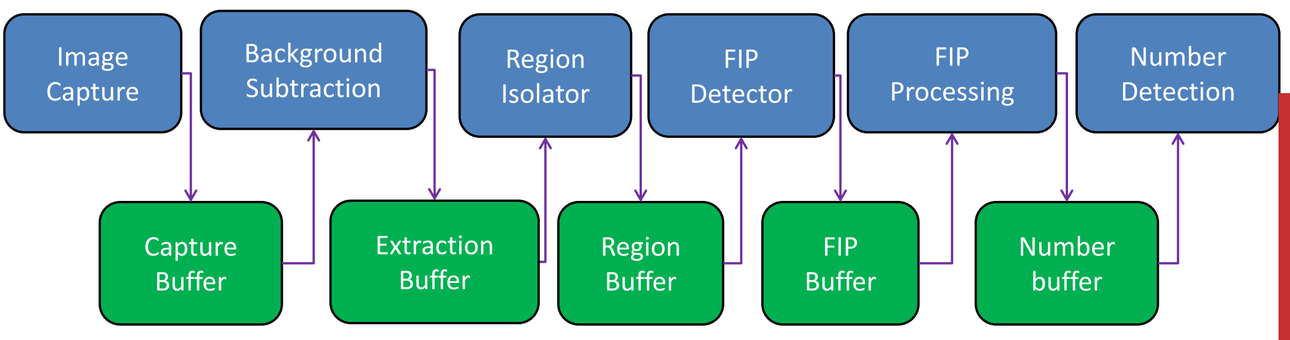
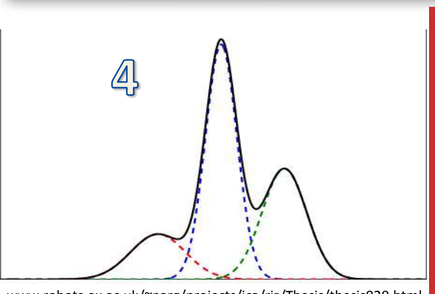


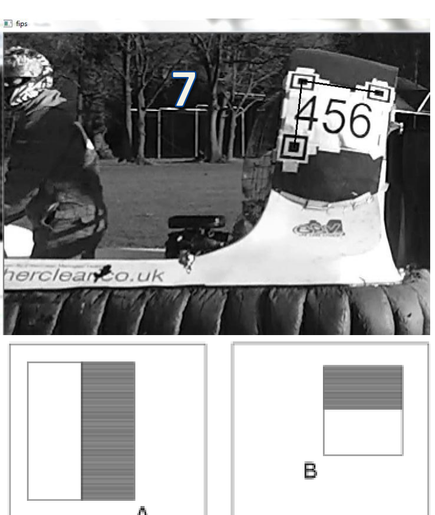
Image Capture / Background Subtraction

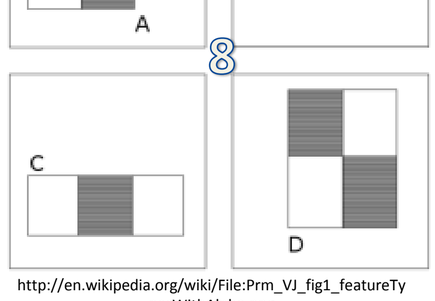


www.robots.ox.ac.uk/~parg/projects/ica/riz/Thesis/thesis029.html

- Capture HD frames at 25FPS
- Captured frames de-interlaced (5,6)
- Background modelled as mixture of Gaussians(4)
- Background Subtraction (1 extracted,2 original) uses SD to allow for real time operation
- Identified regions of interest extracted from HD

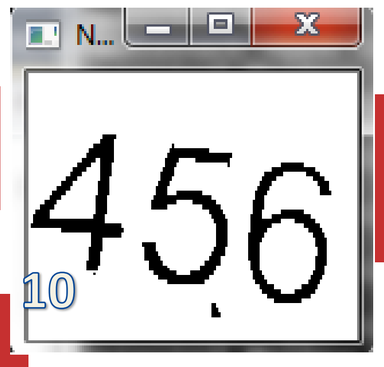
FIP Detection / Processing





http://en.wikipedia.org/wiki/File:Prm_VJ_fig1_featureTypesWithAlpha.png

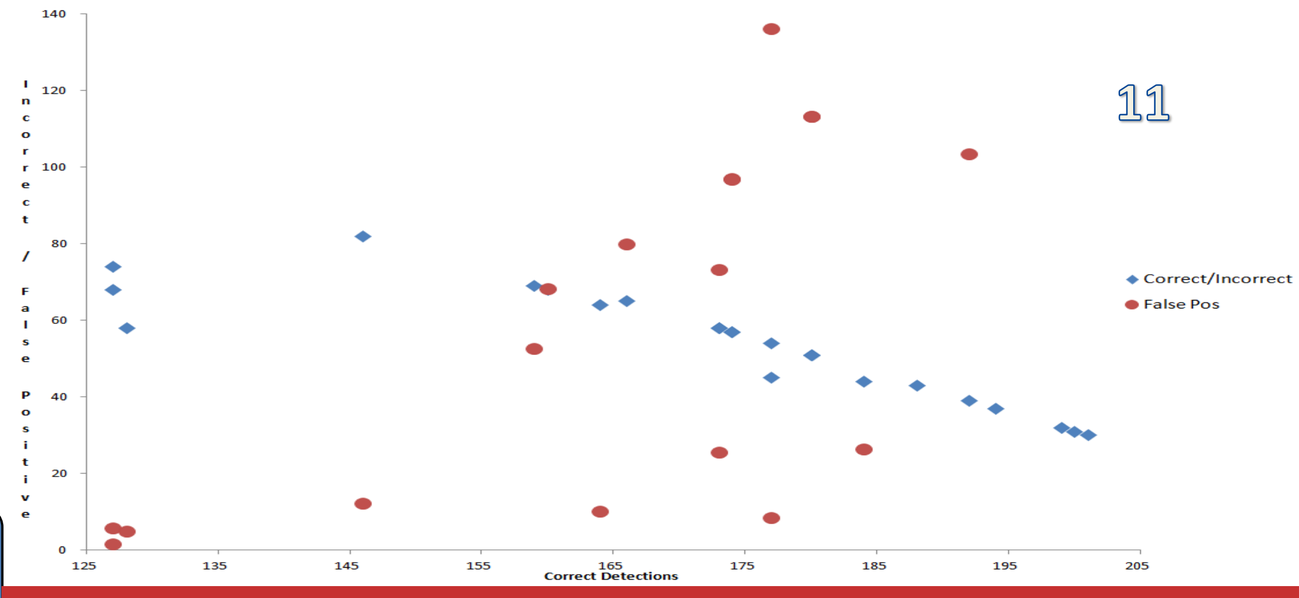
- FIP locator tags same as those found in QR tags
- FIP Detection achieved using OpenCV Viola Jones Cascade
- 5200 Positive and 3400 Negative samples used to train classifier
- Positive samples taken at multiple scales and rotations
- Viola Jones features are the sum of pixel values in clear parts of rectangles subtracted from sum of pixels in the grey parts of rectangles (8)
- Multiple rectangular filters used for each feature(8)
- Detected FIPs joined up into a fully connected graph(3)
- Rotation correction applied to FIPs, invalid edges removed leaving number regions behind(7,9)



OCR

- Threshold applied and FIPs removed from image (10)
- Image then fed to Tesseract OCR engine for identification
- Result returned to the screen

Performance



- Current accuracy rate is 50-60%
- Experimenting with classifier training parameters (number of stages, sample size etc) has yielded improved performance
- Analysis metrics used applied to 1920-1080 images: Correct Detections, False Positives, False Negatives, Correct to False Negative ratio, detection time
- Graph (11) shows correct detection rate of 24 classifiers (X) against Incorrect Detections and False Positives (Y).
- Best performance given by maximising X while minimising Y
- Y False Positive values scaled down by a factor of 10
- False Positives drastically increase detection time per image so must be kept as low as possible
- Some False Positives not shown as are off the end of the Y scale meaning they are too high for consideration

http://www.ecenglish.com/blogs/Cambridge/wp-content/uploads/2012/10/gokarting-race-image-greenwich-docklands-raceway.jpg

Business Plan

- Currently no technology bridges gap between induction loop based systems and human stopwatches with satisfactory accuracy
- Project aims to fill knish where induction loop deemed to expensive or unworkable
- Target market : Go-Karting centres that don't necessarily require very high accuracy but desire fully automated system
- Aim to run business as a franchise where by I recruit a network of independent installers and lease them my solution
- Installers would build own local markets and make money from installations
- Allows me and small team to concentrate on product development
- Lean start-up principles make the business adaptive to end client requirements early in development process maximising value to end customers

Next Steps / Improvements

- Continue improving on accuracy through further classifier development
- Make use of prior probabilistic knowledge in the detection process
  - Craft is unlikely to change much after a few laps into the race
  - Only approximately 15 known numbers on the course at any given time
  - Priors should improve the accuracy of recognition
- Additional challenges :- number not always available due to angle of craft crossing line or failure of detection / OCR process
- Possible solution :
  - Using SURF, SIFT, or FREAK descriptors, build data histogram for each craft
  - Fail over to trained craft descriptor classifier for assessment should number detection fail (12)
  - Allow system to save images from live racing and add them to its database for online learning to increase accuracy over time
  - This solution to be undertaken should time allow

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