



UNIVERSITY OF LEEDS

# An Unsupervised Approach to Anonymous Crowd Monitoring

Ian Hales, Roger Boyle, Kia Ng

`{i.j.hales06, r.d.boyle, k.c.ng}@leeds.ac.uk`

School of Computing,

University of Leeds,

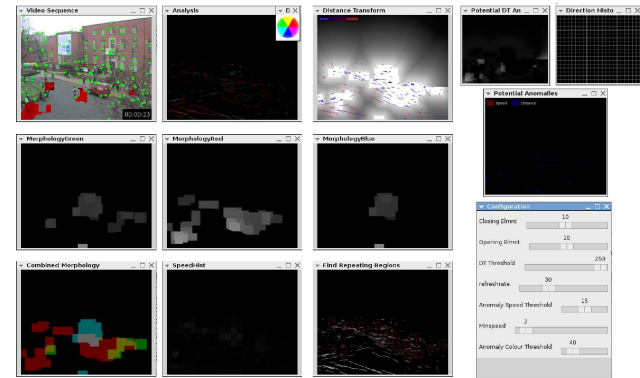
Leeds LS2 9JT

# About Me



UNIVERSITY OF LEEDS

- BSc in Computer Science from The University of Leeds
- 1st year PhD student focusing on crowd monitoring
- Completed a Undergraduate Project in a similar field
- So how is all this relevant to Aerial Analysis and Classification?



# Why?



UNIVERSITY OF LEEDS

- Over 4.2 million CCTV cameras watching over the UK alone.
- Cameras can invade privacy, so we'd like to maintain anonymity.
- Not only benefits to security, also safety and building planning.



# The Aim



UNIVERSITY OF LEEDS

- The high-mounted camera gives a good view of overall motion.
- Using this we aim to build a model of what is and isn't expected.
- Useful to assist an operator by showing them when and where an event occurs.



Play

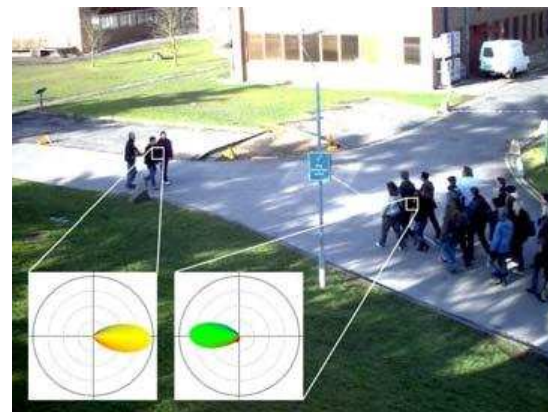
Video from <http://www.earthtv.com>.

# Existing Methods



UNIVERSITY OF LEEDS

- Crowd monitoring is a well established field.
- It is currently exhibiting a surge of interest.
- Many existing methods attempt to isolate individuals - difficult in dense crowds.
- The PETS 2009 workshop is a prime example.



Images from the Eleventh IEEE International Workshop on Performance Evaluation of Tracking and Surveillance (PETS 2009)

# Anonymous Tracking



UNIVERSITY OF LEEDS



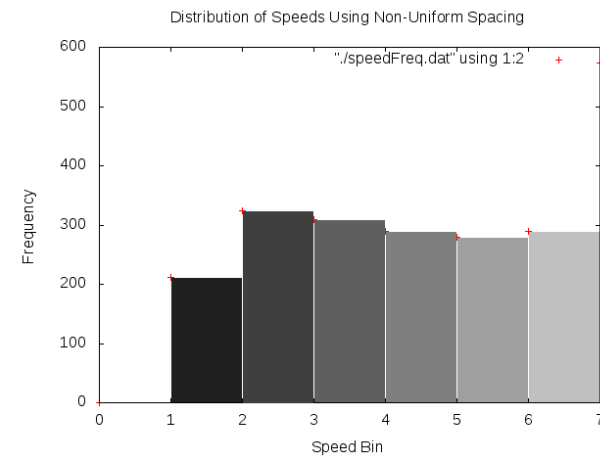
- Find the salient points in the scene.
- Track the points for  $T$  frames using the KLT Tracker.
- Obtain “tracklets”.

# Expectance Model (1)



UNIVERSITY OF LEEDS

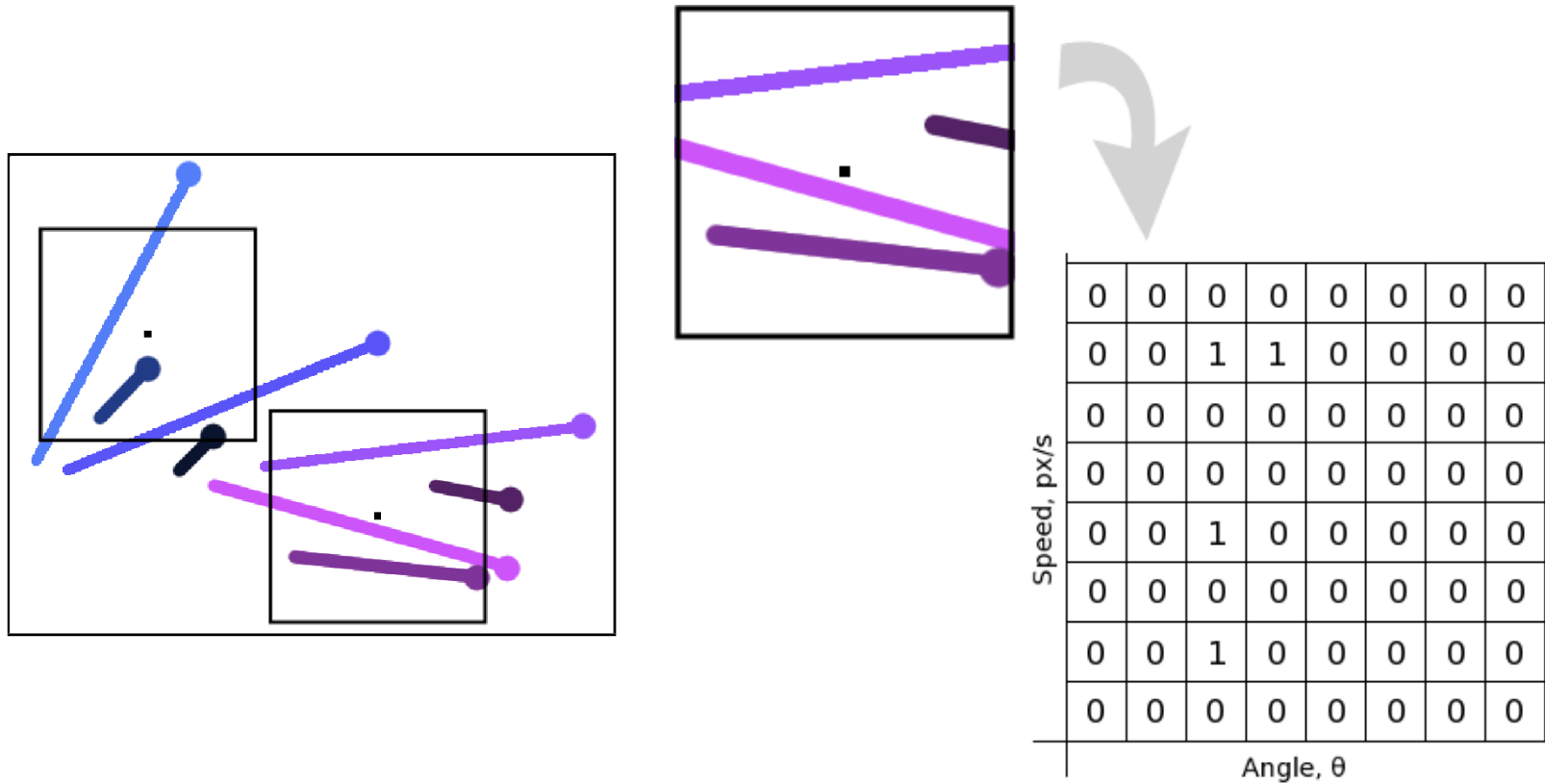
- Unsupervised training to build the model.
- Every  $T$  seconds, gather tracklets within a spatio-temporal sliding window.
- Build a “*motion matrix*” of speed against direction for that pixel.



# Expectance Model (2)



UNIVERSITY OF LEEDS

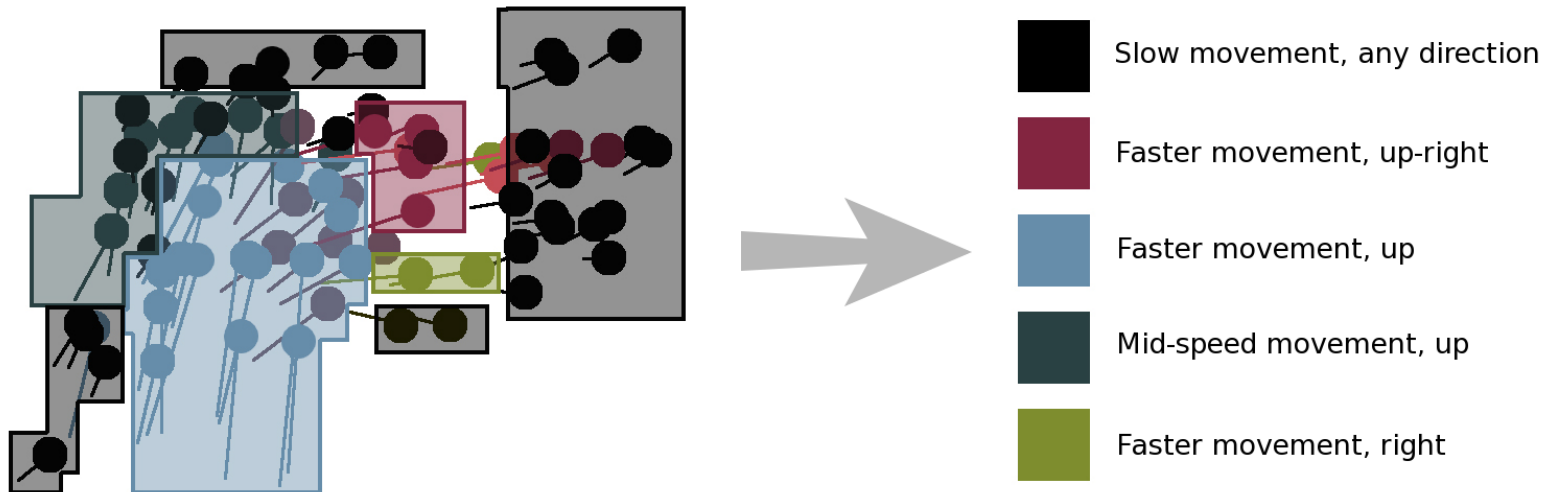


# Expectance Model (3)



UNIVERSITY OF LEEDS

- Take randomly sampled sub-set of matrices.
- Find a suitable number of clusters,  $K$  and cluster using K-Means.
- Cluster centres form a model for expected motion.





# Normality Detection (1)

- Testing phase using the trained model.
- Label each cluster centre,  $p \in \mathbf{P}$  with a colour and intensity.
- Gather tracklets and build motion matrices.
- Each pixel location  $(x, y)$  has a subset of prototypes  $P(x, y)$  associated with it.
- At each time interval,  $t$  find the minimum score,  $s$  between the motion matrix and the recognised cluster centres at each position.

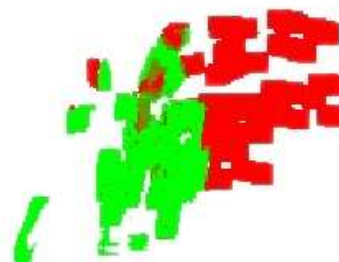
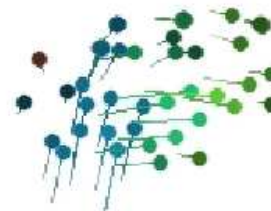
$$(1) \quad s(x, y, t) = \min_{p \in \mathbf{P}(x, y)} \frac{d(m(x, y, t), p)}{\sigma(p)}$$

# Normality Detection (2)



UNIVERSITY OF LEEDS

- The score is a measure of distance against spread. We then make the following assertions:
- $s(x, y, t) \leq 1$  is “*expected*” movement and coloured green.
- $s(x, y, t) \geq 3$  is “*unexpected*” and coloured red.
- $1 < s(x, y, t) < 3$  is “*potentially unexpected*” and coloured with the red and green channels relative to  $d_m$ .



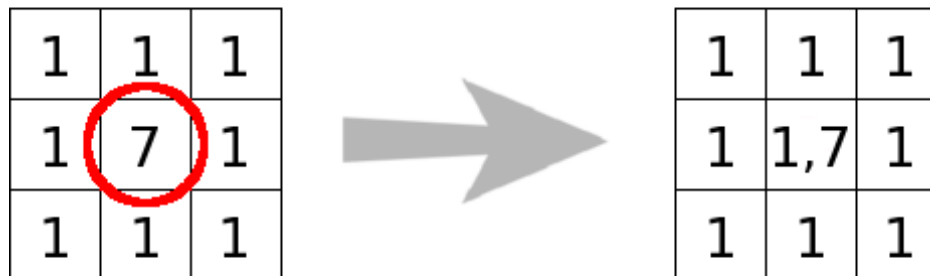
Play

# Further Work (1)



UNIVERSITY OF LEEDS

- Use information from neighbouring windows to improve recognised behaviour.
- Windows of adjacent pixels are likely to contain similar motion, unless at a boundary
- Potential for use of Markov Random Fields



# Further Work (2)



UNIVERSITY OF LEEDS

- Tracklets further from the camera appear shorter even at the same speed
- Due to perspective distortion
- Recapture information about the ground-plane using the tracklets themselves.



Closer tracklets



Further tracklets

Thank you for listening



UNIVERSITY OF LEEDS

# An Unsupervised Approach to Anonymous Crowd Monitoring

Ian Hales, Roger Boyle, Kia Ng

`{i.j.hales06, r.d.boyle, k.c.ng}@leeds.ac.uk`

School of Computing,  
University of Leeds,  
Leeds LS2 9JT

For more information, please visit  
<http://www.leeds.ac.uk/watchingcrowds>.