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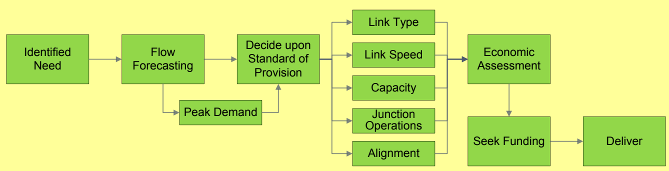
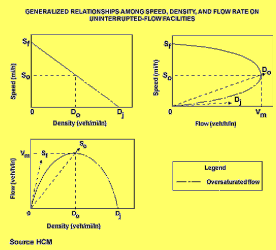
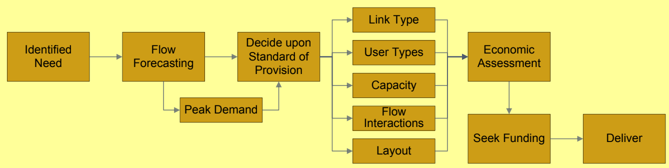
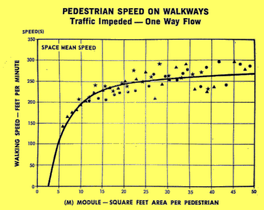
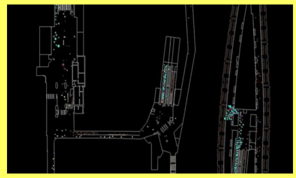
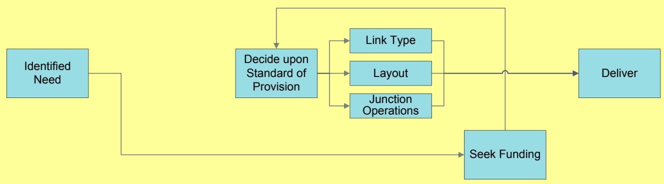
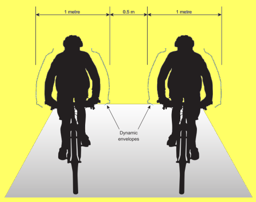
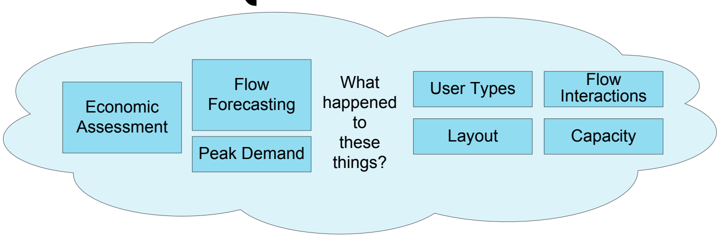
Developing an Evidence-Based Cycle Scheme Design Framework

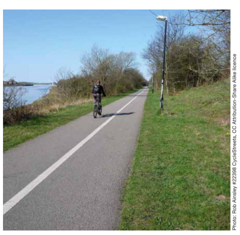
Chris Osowski

Mode	Current Typical Design Process	Fundamentals	Leading Edge Models
			
			
			. . .

Relevant Questions:



- How can we ensure designs get best value for money?
- How can we properly value cycle schemes so the needs of the scheme can drive funding?
- How can we expect the high-quality long-term design of schemes to enable a high-use scenario, when guidance is limited and, at best, designs for:



rather than…

References:

Department for Transport. (2008). *Local Transport Note 2/08: Cycle Infrastructure Design*.

Department for Transport. (2012). *Local Transport Note 1/12: Shared Use Routes for Pedestrians and Cyclists*.

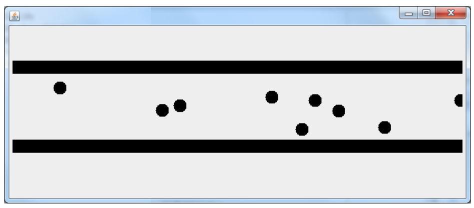
Fruin, J. J. (1971). *Pedestrian Planning and Design* (1st ed., p. 206). New York, NY: Metropolitan Association of Urban Designers and Evironmental Planners Inc.

Transportation Research Board. (2000). *Highway Capacity Manual*. Washington, D.C.: National Research Council.

My Research Work:

Current:

- Develop a cycle model (agent-based) from first principles to define Level of Service Standards for cycle-only flows.



Early version of agent-based model where cyclists (indicated by the black circles) move from left to right, staying within the confines of the cycle track and interacting with one another in accordance with literature-based behavioural traits.

Future:

- Use real cyclists to gather comprehensive data on:
  - Cyclist speed distributions and steering behaviour
  - Cyclist/cyclist passing behaviour
  - Cyclist/pedestrian passing behaviour
  - Cyclist/vehicle passing behaviour
- Use this data to both extend the above model and publish to inform parallel work, elsewhere in industry.

This work is supported by an EPSRC Doctoral Training Centre grant (EP/G03690X/1).

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The Importance of Interactions in Determining Bicycle Levels of Service

Chris Osowski, Ben Waterson, Jason Noble

The lack of agreed and objective measures for cycle service quality and capacity is an increasing barrier to the development of high-quality infrastructure. The measures that are in use – e.g. in the Highway Capacity Manual (TRB, 2010) – are based on assumptions that are demonstrated here to be invalid.

Background

High cycle mode share jurisdictions face issues relating to increased cycle congestion whilst simultaneously, low cycle mode share jurisdictions face increasing calls for investment in cycle infrastructure, yet the ability to economically evaluate proposals is lacking. In both circumstances, a lack of robust quantitative measures is an issue.

Levels of Service (LoS) defined from free flow 'A' to a solid jam at LoS 'F' find wide use in highway and pedestrian modelling and design, but are rarely used for bicycles.

The limited existing LoS measures for cycles are developed based on the "isolated cyclist" (e.g. Botma, 1995) or on a general assumption of non-impedance (e.g. Navin, 1994; and Botma, 1995). By contrast, the fundamental principles of highway traffic flow (and of pedestrian flow) are entirely predicated on the concept of the constituent interactions, with speed-flow/density-flow curves being a well-established and empirically verified result of this.

Research

To assess the importance of interactions between cyclists in service quality and capacity measures for bicycles, an agent-based, 2D microsimulation and social-force model (Helbing & Molnár, 1995) was developed to test the validity of the non-impedance assumptions for unidirectional flow.

The model was then extended to include speed-selection behaviour by the cyclists, informed by the presence of the other cyclists around them.

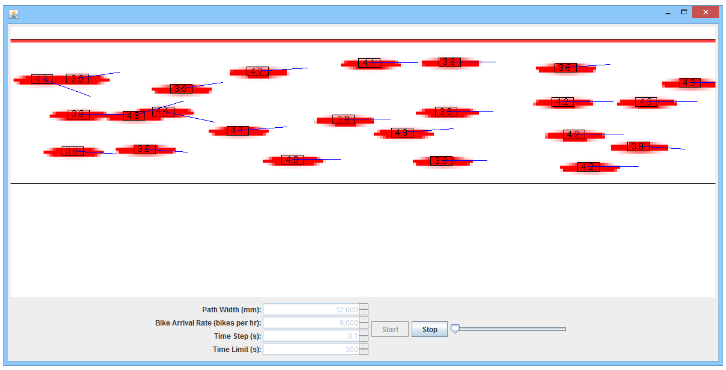
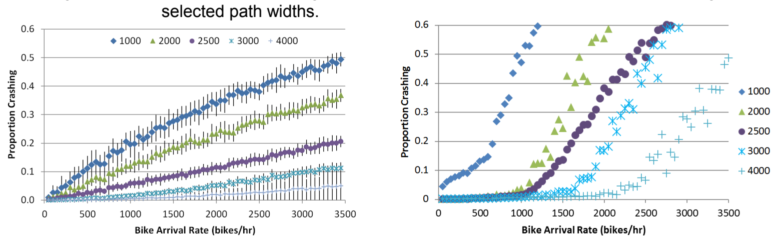


Figure 1: Screen capture of simulation model

Outcome

For bicycles with fixed speed (Figure 2), the interactions were found to be non-trivial both in probability of occurrence and of severity (in that interactions manifest as collisions) across all non-zero arrival rates..

Figures 2 & 3: Crash proportions against arrival rate; fixed speed, left; variable speed, right; for selected path widths.



The incorporation of speed selection behaviour (Figure 3) results in both qualitative and quantitatively different outcomes. Interactions in the context of speed-changing behaviour lead to quantitative outcomes more in keeping with empirical data and experience; and with progressively degraded service manifesting as reduced speeds as opposed to physical collisions (Figure 4 and Table 1).

Figure 4: Levels of Service overlay on combined proximity, velocity and crash outputs.

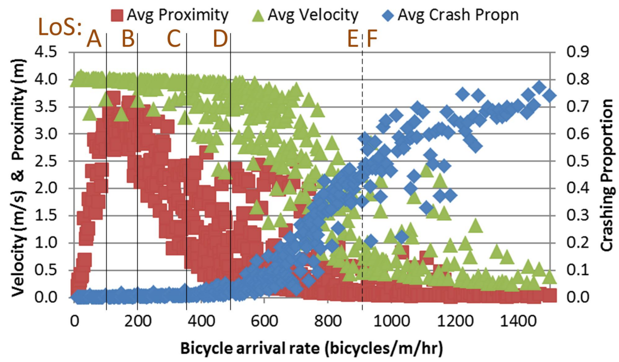


Table 1: Comparative Level of Service thresholds. Osowski (2013) being the fixed-speed results, Navin (1994) being generally empirically derived and Botma (1995) being theoretical and informing TRB (2010).

Source	LoS A/B	LoS B/C	LoS C/D	LoS D/E	LoS E/F
This document	100	200	350	500	900
Osowski (2013)	$\ll$50	$<$50	100	150	$\gg$150
Navin (1994)	800	1600	2800	3400	4000
Botma (1995)	65	130	260	455	650

Conclusion

The results from the simulation model therefore demonstrate the conceptual invalidity of analyses that rely on isolated cyclists or non-interaction, for use in quantitative measures.

References

Botma, H. (1995). Method to Determine Level of Service for Bicycle Paths and Pedestrian-Bicycle Paths. Transportation Research Record, 1502 , 38-44.
Helbing, D., & Molnár, P. (1995). Social force model for pedestrian dynamics. Physical Review E, 51 (5), 4282-4286.
Navin, F. P. D. (1994). Bicycle Traffic Flow Characteristics: Experimental Results and Comparisons. ITE Journal (March), 31-36.
Osowski, C. (2013). The importance of interactions in determining Levels of Service for bicycles (Tech. Rep.). Southampton, UK: University of Southampton.
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Measuring cyclist behaviour from video

Chris Osowski, Ben Waterson

Introduction

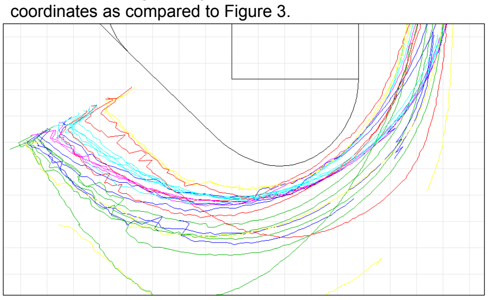
Cycling, as a mode share of urban travel, is widely desired to be increased. To help deliver better infrastructure, robust modelling is needed and demands real-world calibration. This sort of data is expensive to obtain by conventional means which almost always requires substantial manual surveyor time.

This poster demonstrates a process for automating the analysis of video to provide such data. Videos are broken down into their constituent frames and analysis is then performed on a frame-by-frame basis. This analysis gives position by time and yields spatiotemporal data for the cyclists, from which velocity information (amongst other things) can be derived. The video here was obtained from a pilot study in November 2014.

Methodology

Figure 1: Example image of cycles in video study

Figure 4: Computed paths (colour varies by participant) overlaid on a 1m ground grid. Paths are translated to real coordinates as compared to Figure 3.



The process of separating foreground and background was implemented broadly as Snowdon (2008). For the frame being processed, the current pixel is compared to (essentially) the modal value of the pixel throughout the last 5 seconds; sufficient difference being considered to be foreground.

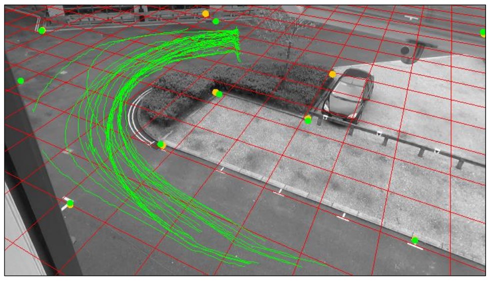
A (two-pass) connected-component labelling algorithm (Shapiro, 2000) was applied to the foreground pixels and each component was then enclosed in a rectangle with a pixel padding. Probable noise is disregarded and overlapping rectangles are 'unioned', linking multiple parts of the same real object (Figure 2).

The process yields a list of frame-indexed rectangle objects. Each rectangle object has a centroid (geometric centre). If a centroid was found in the previous frame within a given radius (10px) then this is considered to be part of the same path. Upon completion, paths shorter than a specified length (25 frames; i.e. 1 second) are removed as likely noise (Figure 3).

A homography matrix is computed for each camera to convert two-dimensional points in the plane of the camera image (i.e. pixel coordinates) to two-dimensional points in the plane of the ground covered by the image (and vice versa). Path vertices were thus able to be converted from image to real coordinates (Figure 4).

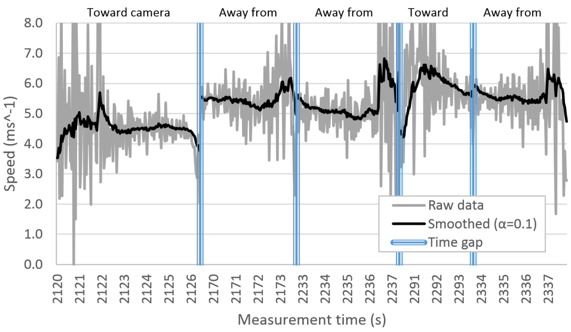
Figure 2: Demonstration of rectangle isolation of a non-background object; i.e. a cyclist.

Figure 3: Computed paths (green) overlaid on background image. Red grid shows a 2m grid estimate for the ground plane created using the homography matrix.



Results

Figure 5: Computed speed profiles for Participant 1



Paths located in time and space allow the derivation of speed information. Cyclist average speeds are considered to fall in the range 4.0ms^{-1} (CROW, 2007) to 6.0ms^{-1} (Parkin, 2010) but sources are limited. Once smoothed to reduce the effect of sampling noise, Figure 5 shows the relatively consistent speeds selected by Participant 1 as they pass through the camera's field of view. Direction of travel is included for reference as the increased noise of data measured further from the camera is apparent. Computed speeds average around 5ms^{-1} ($\bar{x}$=5.25ms^{-1}, σ=0.61ms^{-1}, n=568) which is within the range expected.

Conclusions and Future Work

The analytical process developed for the study videos has already yielded interesting and broadly valid information, in line with expected real-world observations. Speed profiles can be drawn for a given individual and statistical parameters collated.

The next stages for the presented work are refinement. In order to use the process on non-experimental data, the process and algorithms need to be tested and refined on more complex field data. Validation is also required; this will be particularly important in mixed-mode circumstances and complex streetscapes.

The end result of such refinement would be a toolset which provides the ability to use current, historic and future video streams, to analyse traffic without the need for the deployment of specialist equipment.

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Acknowledgements

This work is supported by an EPSRC Doctoral Training Centre grant (EP/G03690X/1).

Thanks also go to Candice Snelling and the NOC Security and Facilities teams for their help in organising the pilot study; and David Arden, Luke Davies, Alex Diem, Ben Lowe, Jono Gray and Vince Marmion for their participation in the event.

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CROW. (2007). *Record 25: Design Manual for Bicycle Traffic*. Ede, Netherlands: CROW.
Parkin, J., & Rotheram, J. (2010). Design speeds and acceleration characteristics of bicycle traffic for use in planning, design and appraisal. *Transport Policy*, *17*(5), 335–341. doi:10.1016/j.tranpol.2010.03.001
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Snowdon, J. (2008). *Using gait to analyse outdoor scenes for automated visual surveillance*. University of Southampton. Retrieved from http://users.ecs.soton.ac.uk/jrs105/Report.pdf