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IntelliBike: condition monitoring of our cycling infrastructure

M. Taylor
Lecturer in Civil Engineering
School of Engineering & the Built Environment
Edinburgh Napier University
10 Colinton Road, Edinburgh, EH10 5DT, UK
e-mail: m.taylor@napier.ac.uk

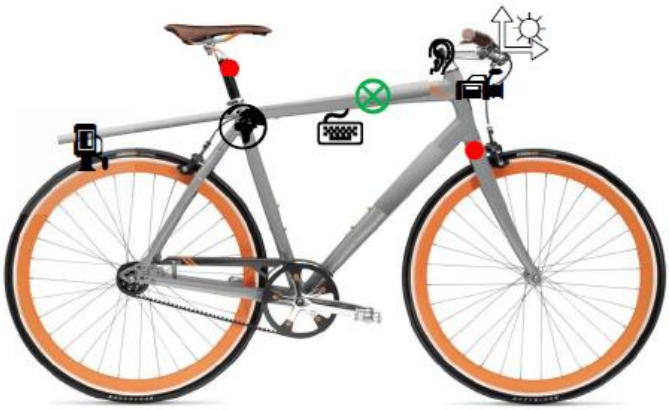
C. A. Fairfield
Professor of Civil Engineering
Edinburgh Napier University
10 Colinton Road, Edinburgh, EH10 5DT, UK
e-mail: c.fairfield@napier.ac.uk

Abstract

This paper presents preliminary designs for the authors' IntelliBike: an innovative instrumented bicycle that can monitor the UK's cycling infrastructure in real-time. IntelliBike will link global positioning system data, real-time camera footage, vibration (ride-quality) data, environmental (noise, light and pollution) data and, depending upon feedback and ideas at conference, extend this into cycle journey analysis and improved lateral vibration monitoring (to enhance the ride-quality monitoring and safety aspects of IntelliBike) along the UK's off-road cycling network. A dedicated software platform will collate all data and provide an asset management tool aimed at better targeted cycling infrastructure maintenance. This applies the principles currently used on-road to cycleways thereby lending this sustainable mode a similar level of technology in its maintenance. The IntelliBike will be a software platform showing streamed video footage of each cycle-way with automated defect and hazard recognition, the correlation of measured on-bike vibrations with running surface quality, the correlation and mapping of camera data onto position data to support the vibration measurements, and the related monitoring/analysis of environmental parameters for the first time across Edinburgh's off-road cycle-way network. Self-funded UK-wide roll-out follows and the intention is to collaborate with EU partners, many of whom will be in the audience here, for extended application.

The proposed research contributes to the development of knowledge and practice in relation to sustainable infrastructure development. The UK's National Cycle Network comprises 16,000 km of running surface (The City of Edinburgh has a 150 km cycle network: 75 km on-road, 75 km off-road). This represents a significant civil engineering infrastructure asset that currently contributes to the provision of a sustainable transport mode option nationwide. Dr Beeching left many UK cities, and rural areas, with an extensive off-road cycle path network. Commuting and recreational cyclists have observed the often hazardous conditions on these paths. Furthermore, Danish and Dutch cyclists have witnessed simple, yet effective, actions taken by local municipalities to tackle cycling infrastructure maintenance issues. There are various simple, effective, measures that could be taken to improve the maintenance of such off-road paths. However, reliance on walk-over surveys and path users notifying the damage reporting agencies (*e.g.* Street Faults Contact Centre, RALF *et al*.) is not tackling maintenance in a resource-efficient manner.

The City of Edinburgh Council's stated 2020 target is for 15% of journeys to be undertaken by bicycle (*c.f.* national target of 10% across Scotland by the same date). Working with The City of Edinburgh Council's Cycling Officer (Mr Chris Brace), Spokes, Cycling Scotland, SUSTRANS, the authors are developing IntelliBike (Figure 1) for trial in Edinburgh and eventual UK-wide roll-out. Recommendations to The City of Edinburgh Council included improvements in the consistency and regularity of monitoring and data reporting.



Symbol	Instrument
⊗	Air quality sensors (2nd on rider helmet)
☼	Light meters (1 horiz. & 1 vert.)
	Sound level meter (or on helmet)
●	Accelerometers
	GPS system
	Cameras (1 horiz. & 1 vert.)
	Data-logger

Figure 1. IntelliBike schematic showing key instrumentation mounting points.

Experts in transportation policy, highway design and key organisations relating to the development of cycling as a mode of transport including: Sustrans, and Cycling Scotland have been consulted. The collecting of asset condition data and the development of a condition monitoring tool from a civil engineering perspective represents a research opportunity. In York, cycle mounted maintenance rangers, each towing a trailer of tools, helped improve cycling facility maintenance [1]. Cycle couriers in Cambridge were recently equipped with sensors that reported air pollution levels with their locations being monitored using mobile telephone signals [2]. Data went *via* Bluetooth to a laboratory where pollutants and exposure levels were recorded.

The Dutch Cyclists Union developed an instrumented bicycle to monitor air and noise pollution in Amsterdam [3]. This registers time, distance, speed, sound, vibrations, and waiting times. The camera mounted on the bicycle recorded the road surface type, its classification, and the construction of intersections and obstacles. It was used to inform decision makers in the re-routing of cycle paths to avoid areas of high air particulate and noise pollution from motor vehicles. In Odense, Denmark, four cyclists are equipped with mobile phone cameras for photographing defects to send to the roads and parks maintenance officer with a text description and location. The scheme included payment for each accepted message. This type of scheme is used for maintenance defects in Lothian through the 'Clarence' phone line, but represents a reactive approach rather than IntelliBike's preventative approach to the management of cycling infrastructure.

An instrumented bicycle was used to measure particulate matter exposures along bicycle routes through a variety of land uses over summer in Vancouver. The data were used to help cyclists weigh-up the risks of bicycle commuting, and planning engineers as they sought optimal designs for designated cycle-ways [4]. No cycling infrastructure decision support tool to assist in the allocation of funds to maintenance was found: the IntelliBike's linkage to engineering asset management is novel.

References

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[4] A. Thai, I. McKendry, & M. Brauer, "Particulate matter exposure along designated bicycle routes in Vancouver, British Columbia", *Sci. Total Environment* **405** (2008), pp. 26-35.