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J. Aaron Hipp

*Washington University in St. Louis, Brown School, ahipp@wustl.edu*

Deepti Adlakha

*Washington University in St. Louis, Brown School, deeptia@wustl.edu*

Bill Chang

*Washington University in St. Louis, Computer Science and Engineering, billchang@wustl.edu*

Amy A. Eyler

*Washington University in St. Louis, Brown School, aeyler@wustl.edu*

Robert B. Pless

*Washington University in St. Louis, Computer Science and Engineering, pless@wustl.edu*

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**Emerging Technologies:  
Webcams and Crowd-Sourcing to Identify Active Transportation**

J. Aaron Hipp, PhD<sup>1,2\*</sup> Deepti Adlakha, MUD<sup>1</sup> Bill Chang, BS<sup>3</sup> Amy A. Eyler, PhD<sup>1,2</sup>  
Robert Pless, PhD<sup>3</sup>

Washington University in St. Louis: <sup>1</sup>Brown School of Social Work, <sup>2</sup>Prevention  
Research Center, and <sup>3</sup>Computer Science and Engineering

\*One Brookings Drive, Washington University in St. Louis, Campus Box 1196  
Saint Louis, Missouri 63130

[o] 314.935.3868 [f] 314.935.8511 [e] [ahipp@wustl.edu](mailto:ahipp@wustl.edu)

## **Introduction**

Over 25% of adults in the US are obese,<sup>1</sup> contributing to 300,000 deaths and costing the US healthcare system \$147 billion annually.<sup>2</sup> Federal governments to local non-profit agencies have instituted policy and built environment (BE) changes in effort to reduce obesity and increase physical activity (PA). A challenge in evaluating the success of policy and BE change is the capacity to capture *a priori* PA behaviors and the ability to eliminate researcher and respondent bias in assessing post-change environments. A novel transdisciplinary collaboration between public health and computer science is presented here with the goal of automatically analyzing existing public data feeds in innovative ways to quantify BE intervention effectiveness.

## **Methods**

The Archive of Many Outdoor Scenes (AMOS) has collected over 225 million images of outdoor environments from more than 12,000 public webcams since 2006.<sup>3</sup> AMOS uses publicly available webcams and a custom web crawler (similar to web search engine or Google) to capture webcam images with a time stamp, capturing one photographic image per camera each half hour.<sup>4</sup> Many of these environments have experienced BE improvements or policy change (e.g., complete street policies, bike shares, and walking school bus programs). AMOS provides a unique opportunity to measure BE change and associated behavioral modification.

Available webcams were spatially matched with policy and BE changes, identifying pilot areas in the US that have instituted BE change since 2006. One example is the addition of protected bike lanes and a bike share program in Washington, DC, during 2009/2010.

An AMOS webcam captured example BE change (addition of cycle paths; Figure 1) at the intersection of Pennsylvania Avenue NW and 9<sup>th</sup> Street NW. Using the AMOS dataset, all 120 webcam photographs were captured between 7:00am and 7:00pm during the first work week of June 2009 and the 120 photographs were captured from the same week of June 2010. The use of this captured webcam data allowed for a pre-cycle path and post-cycle path travel mode analysis.

The Amazon Mechanical Turk (MTurk) website was used to crowd-source the image annotation.<sup>5</sup> MTurks are simple tasks that have not yet been automated by computers. MTurk workers were paid US\$0.01 in March 2012, to mark each pedestrian, cyclist, and vehicle in a photograph. Each image was counted 5 unique times (n=1200), a process completed in under eight hours. Counts per transportation mode were downloaded to SPSSv.19 for analysis in April 2012. The odds of observing each transportation mode in year two compared to year one was examined and a MANOVA conducted to establish overall mode variance between the years. With five unique workers, the range and variance of counts differed per photo. A test for difference in variation between the two years was not significantly different for any one travel mode. Recent research has revealed MTurk workers to be reliable.<sup>6,7</sup>

## Results

The odds of the webcam at Pennsylvania and 9<sup>th</sup> capturing a cyclist present in the scene in 2010 increased 3.5 times, compared to 2009 (OR=3.57,  $p<0.001$ ). The number of cyclists per scene increased four-fold between 2009 (mean=0.03; SD=0.20) and 2010 (0.14; 0.90;  $F=36.72$ , 1198;  $p=0.002$ ), associated with the addition of a new cycle path in the captured webcam scene. There was not a significant increase in pedestrians between years, but there was a significant increase in number of vehicles ( $F=16.81$ , 1198,  $p<0.001$ ; see Figure 1). Overall, the MANOVA test revealed a statistically significant difference in transportation mode share between the two years ( $F(3, 1196) = 11.265$ ,  $p<0.001$ ).

## Discussion

Findings suggest publicly available web data feeds and crowd-sourcing have great potential for capturing behavioral change associated with BEs. The addition of cycle paths at Pennsylvania and 9<sup>th</sup> was associated with a significant four-fold increase in the number of cyclists captured per scene.

This initial, novel research presents an unobtrusive surveillance of the effectiveness of a PA policy and BE intervention. The use of public webcam scenes and MTurks offer an inexpensive (US\$12.00) means for public health, urban design, and governments to evaluate effectiveness of BE policy change and interventions. Future research includes testing with additional bike lane scenes in Washington, DC and expanding to include

parks and safe routes to schools. Current efforts are also focused on the utilization of computer algorithms to automate the counting of transportation modes per scene.

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**Figure. 1:** Images of (A) pre-cycle path (2009), and (B) post-cycle path (2010) built environment improvement in Washington, DC, from AMOS; (C) Graph showing significant increase in cycling ( $p < .001$ ).



**A.**

**B.**

