Pedestrian Collision Warning for Buses

DOT Goal: Safety; Topic: Technology-Related Research

Principal Investigators
Daniel D. Lee
Camillo J. Taylor

Researchers
Alex Burka, ESE
Alaric Qin, ESE

Collaborators
Justin Aird
Marcus Pan
Yida Zhang, MSE
Rahul Bhan, ESE
Nikhil Karnik, ESE
Jordan Parker, ESE
Vaibhav Wardhen, ESE
Thomas Boutin, CIS

Abstract

We propose the development of a system that detects and warns pedestrians of an impending collision. GPS and IMU fusion technology will be used to analyze bus motion, and different sensor technologies will be investigated to detect pedestrians and estimate collisions. Identification algorithms will be proposed to trigger alarm and broadcast warning message through various channels.

Project Status

Start Date: September 2012
End Date: July 2014
Status: Active

Sponsoring Organizations:
- Research and Innovation Technology Administration
- University Transportation Centers Program
- U.S. Department of Transportation

Problem Statement

Fatal bus and pedestrian collisions have seen a sharp uptick in the last decade. While the causes for such an increase are varied, one primary driver of the trend is the rise of a phenomenon known as "distracted walking," which occurs when pedestrians are distracted from the primary task of walking by electronic devices. Such behavior potentially accounts for a significant portion of the increased number of bus pedestrian accidents seen in the past decade. As reported by SEPTA, most of these accidents happen while buses are turning at dense urban intersections - precisely the type of intersection where vigilance and attention to one's surroundings is absolutely critical.

The increase in the frequency of bus and pedestrian collisions is a looming liability for SEPTA and other transit agencies across the country, pedestrians that have been injured file suit. It is estimated that such claims cost SEPTA over $40 million per year in compensation and legal fees. Thus, the financial losses from increased collisions, though secondary to the critical issue of pedestrian life loss, are nonetheless important to SEPTA and other cash-strapped agencies - making critical the development of a system which can prevent such accidents from occurring.

Goals for this Project

- To construct a system that detects when a bus is making a turn at an intersection
- To construct a system that adequately warns the pedestrian and bus driver when there is a risk of a collision
- Noticeability, ensuring that at least 70% of pedestrians will recognize and react to the warning in an urban environment
- Simplicity, ensuring that the system takes less than 30 minutes to install, without requiring interference with the vehicle's existing electrical systems
- Robustness, operating to desired responsiveness and noticeability standards in a variety of conditions, including rain, fog, snow, and at night

1) Greater Cleveland Regional Transit Authority. (2011). 2011 APTA Bus Awards Submission: Advancing GCRTA's Safety Culture to Reduce Employee Injuries, Eliminating Left & Right-Hand Turn Bus-Pedestrian Collisions. Retrieved November 7, 2012 from America Public Transit Association: http://www.apta.com/members/memberprogramsandservices/awards/Documents/APTA- 2011-Bus-Safety-Awards-GCRTA.pdf
2) Roberts, C. (2011, September). AC Transit Pays $10.5M to Woman Hit By Bus. Retrieved September 28, 2012 from NBC Bay Area: http://www.nbcbayarea.com/news/local/AC- Transit-Dishes-Out-105-Million-To-Woman-Hit-By-Bus-129739578.html
3) Jury Awards Woman $20M+ in Damages after Queens Bus Accident. October 3, 2011. Retrieved September 28, 2012, from http://www.newyorkinjurylawyersblog.com/2011/10/jury-awards-woman-20m-in- damag.html
4) SEPTA Accidents. (n.d.). (Retrieved September 27, 2012, from http://www.jaffehough.com/practice-areas/septa-accidents/

Bus Tracking and Motion Estimation

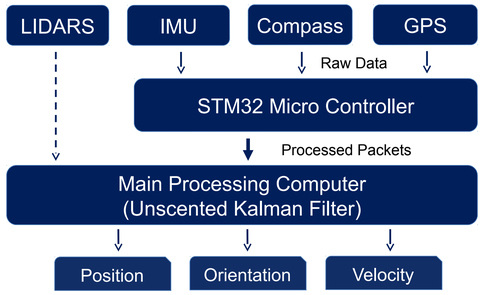


Figure 1: Bus Motion Detection System Architecture

Prototype Hardware Design

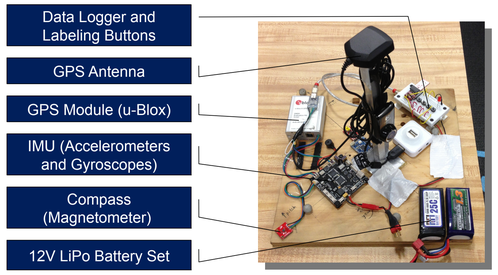


Figure 2: Hardware Design of the Prototype System

- All sensor raw data are processed on single board
- Powered by 12VDC which is available on bus
- Standalone and no modification required for bus
- All standard and low cost components

Preliminary Bus Tracking Result

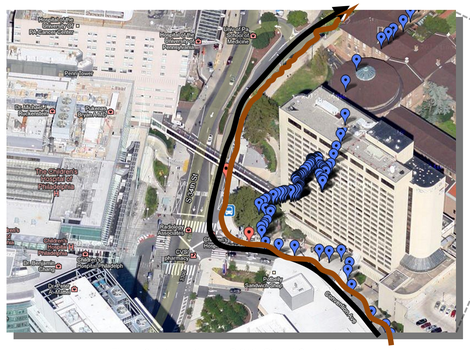


Figure 3: Intersection on S 34th St and Convention Ave

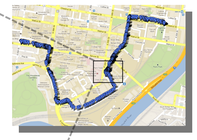


Figure 4: Whole Path in Data Set

Figure 5: Device Position on the Bus

Place markers given by GPS Module

Manually labeled turning starting and ending place marker

Actual bus operating trajectory on this intersection

Filtered trajectory estimated from IMU, GPS and Compass data

The prototype system has been placed on Bus Route 42 and collect data for Unscented Kalman Filter (UKF) to estimate and track the bus position.

LIDAR based Pedestrian Detection

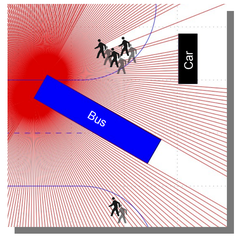


Figure 6: Two LIDAR simulation

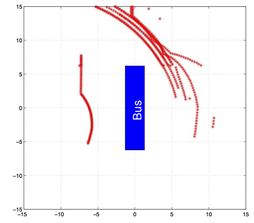
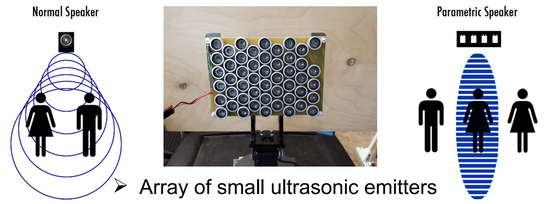


Figure 7: Pedestrian Moving Trajectory in bus frame

- Two LIDARs are installed on both front corners of a simple bus model, which covers full front view
- The bus makes a left turn as Route 42 does on the 34th and Walnut Street intersection
- Four pedestrians have been placed on two corners of the intersection along with a waiting vehicle
- Results indicate the minimum detection distances to the bus

Hokuyo UTM30LX
Max Range: 30m
Angles Range: 270o

Directional Audio



- Array of small ultrasonic emitters projects sound directly towards a target
- Minimize disruption and noise pollution while alerting pedestrians to danger
- Proof of concept device is now available for demonstration and testing

Future Work

- The LIDARs will be properly installed on buses and collect data for more complex pedestrian detection
- The directional audio warning system will be further developed and tested in the outdoor environment
- Machine learning algorithms will be used to predict turning starting moment based bus motion information and pedestrian detection, and to fine-tune the directional speaker parameters

Technologies for Safe and Efficient Transportation

A U.S. DOT UNIVERSITY TRANSPORTATION CENTER