Leveraging Signal Infrastructure for Nonmotorized Counts in a Statewide Program

Pilot Study

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Transportation agencies are beginning to explore and develop nonmotorized counting programs. This paper presents the results of a pilot study that tested the use of existing signal infrastructure—Model 2070 signal controllers with advanced software to log pedestrian phase actuations and detections from bicycle lane inductive loops—to count pedestrians and bicycles. The pilot study was conducted at a typical suburban signalized intersection with heavy motorized traffic that was instrumented on all four approaches with pedestrian push buttons and advance inductive loops in the bicycle lane for signal operation. One day (24 h) of video data was collected as ground truth. The data were reduced and compared with the controller logs. Results indicated that using pedestrian phases as a proxy for estimating pedestrian activity was a promising avenue for counting programs. During the pilot study day, 596 pedestrians crossed the intersection, and 482 pedestrian phases were logged (i.e., 1.24 pedestrian crossings per phase logged). However, bicycle counts were not as accurate because of a number of site-specific factors: (*a*) inductive loop location, (*b*) loop sensitivity settings, (*c*) loop shape, and (*d*) nearly half of the cyclists passing through the intersection were riding on the sidewalk. The pilot study was part of a research project to develop guidelines for a statewide bicycle and pedestrian counting program for the Oregon Department of Transportation.

Nonmotorized transportation modes are receiving more attention from transportation agencies at federal, state, and local levels. There is also growing interest in standardizing counting procedures for nonmotorized modes. Currently, there are no federal or state requirements for nonmotorized traffic counting. Pedestrian and bicycle data collection methods vary widely for each jurisdiction and research or data collection purpose. The rationale for data collection of nonmotorized traffic data is primarily related to safety and infrastructure investments. In contrast, published research reports and papers are more concerned with the performance of data collection equipment used in nonmotorized data collection and data trend analysis.

In general, count data collection sites are chosen to cover different types of facilities (e.g., commuter versus recreational) and local knowledge of areas of high nonmotorized usage. Although some agencies in the United States are moving to mostly automated data collection equipment and practices (e.g., Colorado), most bicycle and pedestrian data are still collected manually, sometimes as part of the National Bicycle and Pedestrian Documentation Project (*1, 2*). In Europe, Australia, and New Zealand, most decisions about bicycle infrastructure are made on the basis of household surveys and do not require count data collection to verify usefulness of nonmotorized facilities (*3*); however, London includes bicycle traffic as part of its roadway data collection system and other agencies in Australia and New Zealand also collect bicycle count data.

Counting pedestrians and bicycles can be more challenging than counting motorized vehicles, because of the differences in the predictability of their movements, a lower degree of channelization, and other difficulties. There are many different technologies used for counting bicycles and pedestrians. Because of space limitations, a review of different technologies is not included in this paper; rather, readers are referred to the associated project report (*4*) and NCHRP Report 797 for more information (*5*). One approach that appears feasible in some situations is the use of data logging capabilities of advanced signalized intersection traffic controllers (*6*). Intersections are ideal candidates because travel paths are defined for nonmotorized travel and infrastructure (with respect to power and communication) often exists. Among all the available counting technologies for bicycles and pedestrians, leveraging signal controllers could be potentially cost-effective.

This paper presents the results of a pilot study, which comprised a 24-h bicycle and pedestrian count at a signalized intersection in Oregon. All four approaches were instrumented with pedestrian push buttons and advance inductive loops in the bicycle lane for signal operation. Bicycles were counted using inductive loops installed in the bike lanes at all four approaches to the intersection, while pedestrian phases were logged as a proxy for counting pedestrians. After presenting the results of the 24-h count, an example application of the results is given. Finally, lessons learned from the pilot study are summarized.

SITE DESCRIPTION

The 24-h pilot study was conducted at the intersection of OR-99W and Hall Boulevard in Tigard, Oregon. Contextual and aerial views of the site are shown in Figure 1. Land uses around the intersection were generally commercial, including suburban shopping centers

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Transportation Research Record: Journal of the Transportation Research Board, No. 2527, Transportation Research Board, Washington, D.C., 2015, pp. 69–79.
DOI: 10.3141/2527-08

FIGURE 1 OR-99W and Hall Boulevard, Tigard.

(with large parking facilities) and a car dealership. This site was selected because it met several criteria. First, it represented a typical Oregon Department of Transportation (DOT) suburban intersection. There was also already a reasonable amount of pedestrian and bicycle traffic. Finally, a Model 2070 signal controller with pedestrian push-button phase actuation (for all crosswalks) and connected bicycle lane inductive loops were already installed.

Pedestrians

At signalized intersections with pedestrian phases granted by a traffic signal, pedestrian phase data can be recorded and retrieved using software. There are two main types of pedestrian signal phasing configurations:

1. Pedestrian phase in recall. Some intersections with pedestrian recall have push buttons, but regardless of whether a pedestrian pushes the button, a pedestrian phase is granted (usually at the minor approach). A pedestrian push button at an intersection with pedestrian recall is provided so that pedestrians understand that there is a pedestrian phase and that they have to wait for the pedestrian signal.
2. Actuated pedestrian crossings grant the pedestrian signal phase only when the pedestrian button is pushed. A photo of a pedestrian button at the northwestern quadrant of the pilot study intersection is presented in Figure 2.

If the pedestrian phase is in recall, using pedestrian phase logging as a measure of activity is erroneous, as the pedestrian phase will be logged as served during every cycle. The intersection studied here was an actuated pedestrian crossing, meaning that pedestrian phases were granted only when the actuation button was pushed (i.e., the pedestrian phase was requested).

Using logged pedestrian phases as a proxy for estimating pedestrian activity is a relatively new concept, and it is still at the research and validation stage. Besides installing the necessary software, the only additional cost of collecting pedestrian phase logs is the downloading and evaluation of the data. Data collection costs are reduced if a router or wireless data transmission service is available or the controller is on a central signal system.

Bicycles

Inductive loops detect moving metal objects by measuring changes in inductance within the loop caused by the movement of metals in close proximity. Inductive loops have long been used to detect automobiles and can also be applied to detecting bicycles. Inductive loop wires are routed to the controller channel designed for counting.

In Figure 3, the locations of the inductive loops for detecting bicycles are highlighted, with two bicycle lane loops each on the southbound and northbound approaches and one each on the eastbound and westbound approaches. The bike lanes on the southbound and

FIGURE 2 Pedestrian phase actuation button (northwest quadrant of intersection of OR-99W and Hall Boulevard, Tigard).

northbound approaches had both an approach detection loop located about 50 ft in advance of the stop bar to detect cyclists approaching the intersection and a loop at the stop bar to detect cyclists stopped at the intersection. The eastbound and westbound approaches only had the approach detection loops. Three cameras were placed in the northwest corner of the intersection, mounted on a signal pole above the reach and out of the typical field of view of passing pedestrians. The cameras were angled to get the maximum possible view of the entire intersection and approaches.

The pilot study data collection was conducted from 9:00 a.m. on Thursday, August 29, 2013, until 9:00 a.m. on Friday, August 30, 2013. During this 24-h period, video was recorded so that bicycle and pedestrian traffic could later be manually counted for the entire intersection to validate the automated data collection.

RESULTS

Pedestrians

Pedestrian crossings were counted manually from the 24-h video recording. These counts were compared with the phase counts logged in the signal controller during the same time period. Hourly pedestrian volumes are presented in Figure 4. The peak hours of pedestrian traffic occurred between noon and 6:00 p.m.; these 6 h account for 43% of the total pedestrian daily volume of 596 pedestrian crossings. Each pedestrian as graphed in Figure 4 represents a single pedestrian movement (i.e., one person crossing in a single direction). If a single person crossed two crosswalks at the intersection, this action was counted as two pedestrian movements.

The group size of pedestrian crossings was also documented from the video analysis. Group size refers to the number of pedestrians crossing in a single direction during a single pedestrian phase. Figure 5 presents information about the pedestrian group sizes observed over the 24-h video data collection period.

Single pedestrians were the most common group size observed, but groups of two were observed 57 times. Other group sizes were observed less frequently, as illustrated in Figure 5. In total, there were 440 groups of pedestrians observed and a total of 596 pedestrian crossings over the 24-h study period, resulting in an average group size of 1.35 pedestrians per group.

To assess the validity of using the Model 2070 signal controller phase logs to estimate pedestrian activity, the video counts and the logged phase counts were compared. Table 1 presents a summary of the pedestrian counts and logged pedestrian phases. Volumes are separated by the location of the crosswalk with respect to the intersection (see Figures 1 and 3). Directionality of pedestrian travel cannot be inferred from the Model 2070 signal controller phase logs; only the phase associated with each crosswalk is reported. The northern, southern, and western crosswalks had more pedestrian volume than pedestrian phases granted, which is the result of more than one pedestrian crossing within a phase (as shown in Figure 5). The eastern crosswalk had fewer pedestrian movements than phases granted, likely because of a combination of pedestrians pushing the actuation buttons for two directions at one time and cyclists pushing one of the corresponding actuation buttons.

The ratios given in the bottom row of Table 1 can be used to develop adjustment factors for estimating pedestrian volumes from the counts of phases granted reported by the Model 2070 controller. To explore the variation of these factors throughout the day, scatter plots in Figure 6 depict the relationship between pedestrian phases granted and the actual pedestrian volumes per each hour of the 24-h study period (24 data points per graph). There is a linear relationship with an R^2 value of at least .70 for each crosswalk. The analysis at this location suggests that it might be possible to make a reasonable estimate of pedestrian volumes from pedestrian actuations at the pilot study intersection using the adjustment factors shown in Table 1. However, these adjustment factors are clearly site and context specific. Further research is necessary to determine the scope and methods required to generalize these finding to other days or locations.

Bicycles

The video counts were used to characterize the bicycle traffic patterns at the intersection studied. Figure 7 presents the total hourly bicycle volumes during the first video analysis period, as well as the hourly bicycle volumes counted traveling in the bicycle lane. It was discovered that bicycle lane volumes represented only 51% of the total bicycle volume observed. The other 49% of cyclists were traveling on the sidewalk. This finding is especially important to note

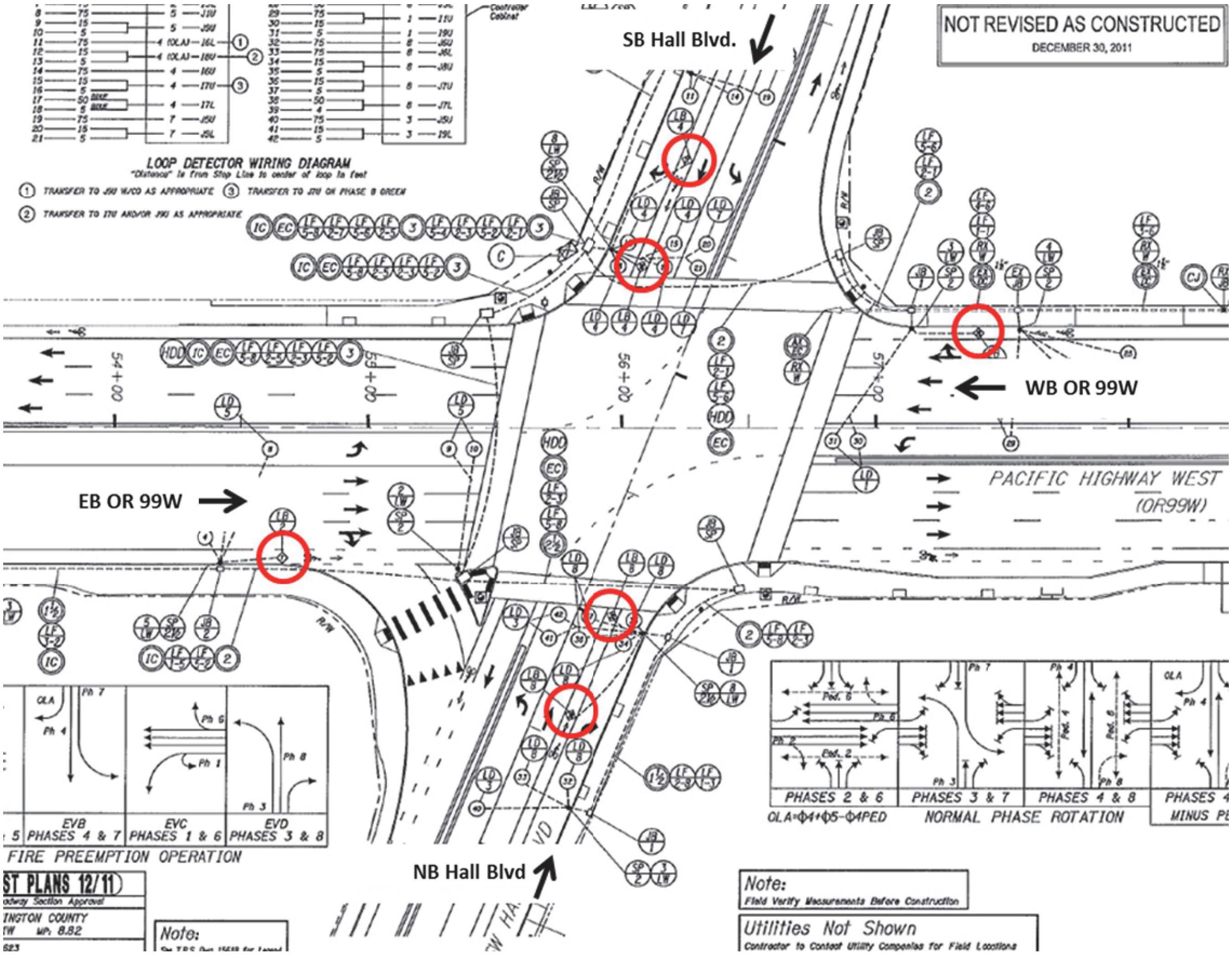

FIGURE 3 SW 99W and Hall Boulevard intersection plan (inductive loops circled in red; SB = southbound; EB = eastbound; WB = westbound; NB = northbound).

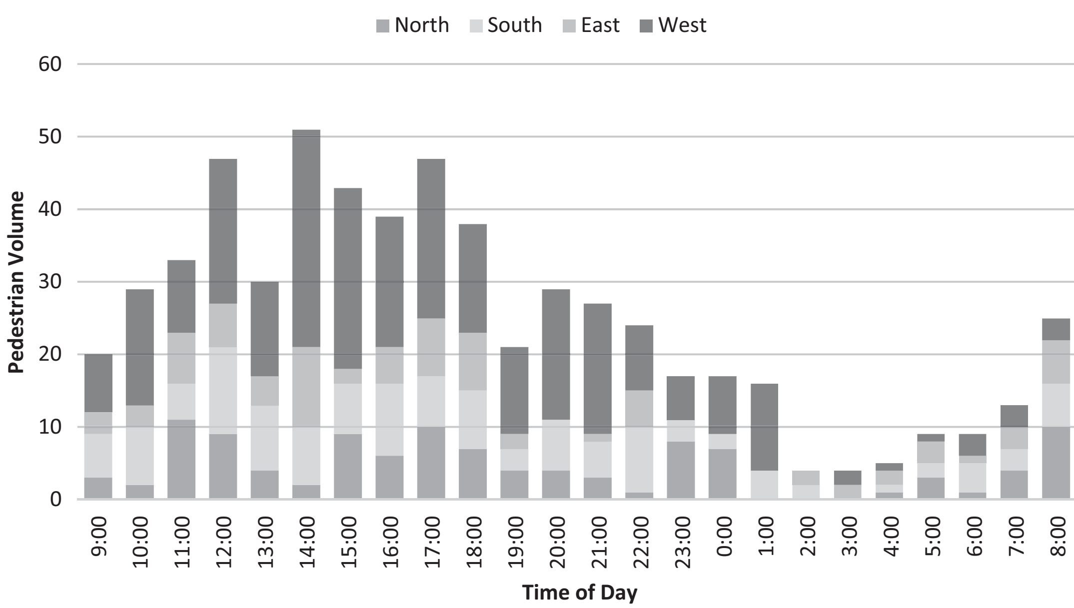

FIGURE 4 Hourly pedestrian volumes over the course of pilot study period (9 a.m., August 29, 2013, to 9 a.m., August 30, 2013).

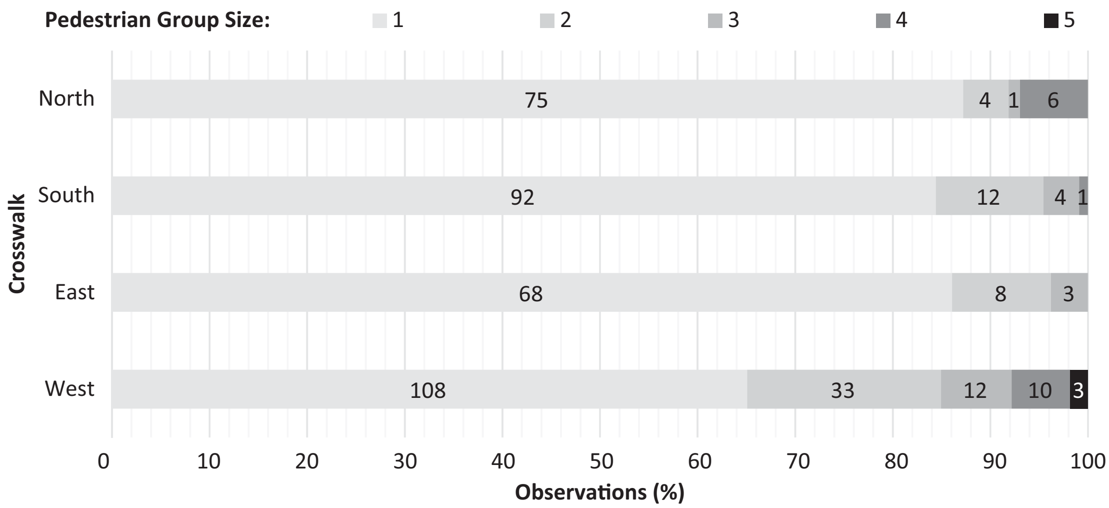

FIGURE 5 Pedestrian group size stratification (data labels = number of observations).

TABLE 1 Video Counts Versus Model 2070 Signal Controller Pedestrian Phase Counts Summary

Parameter	Count, by Crosswalk North	South	East	West	Total
Pedestrian volume (video counts)	109	131	84	273	596
Pedestrian phases logged (Model 2070 data)	91	109	100	182	482
Ratio (pedestrians per phases)	1.20	1.20	0.84	1.50	1.24

if factors are to be developed for estimating actual bicycle volumes from loop detections, because the bicyclists using the sidewalk are not detected by the inductive loops. Also, Figure 7 shows that the peak bicycle volume on the day of video collection for total bicyclists is from 4 to 5 p.m., while for bike lane riders it is 1 h later. This finding indicates that cyclists riding on the sidewalk may have different travel patterns than those using the bike lane.

To quantify the counting accuracy of the inductive loops, the manual video counts were compared with the bicycle volumes recorded by the Model 2070 controller (detected by the inductive loops). On analyzing the bicycle volumes collected from the video analysis, it became clear that the bicycle counts logged were much higher than

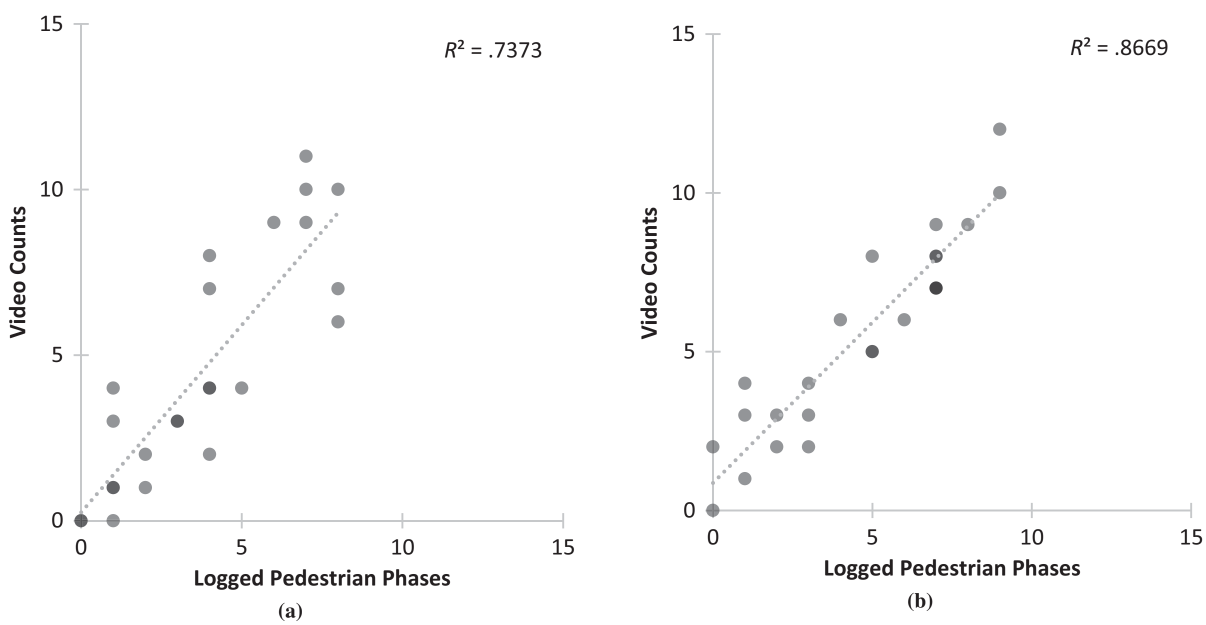

FIGURE 6 Scatter plots of hourly video counts versus hourly logged pedestrian phases: (*a*) north crosswalk and (*b*) south crosswalk (darker points = multiple observations).

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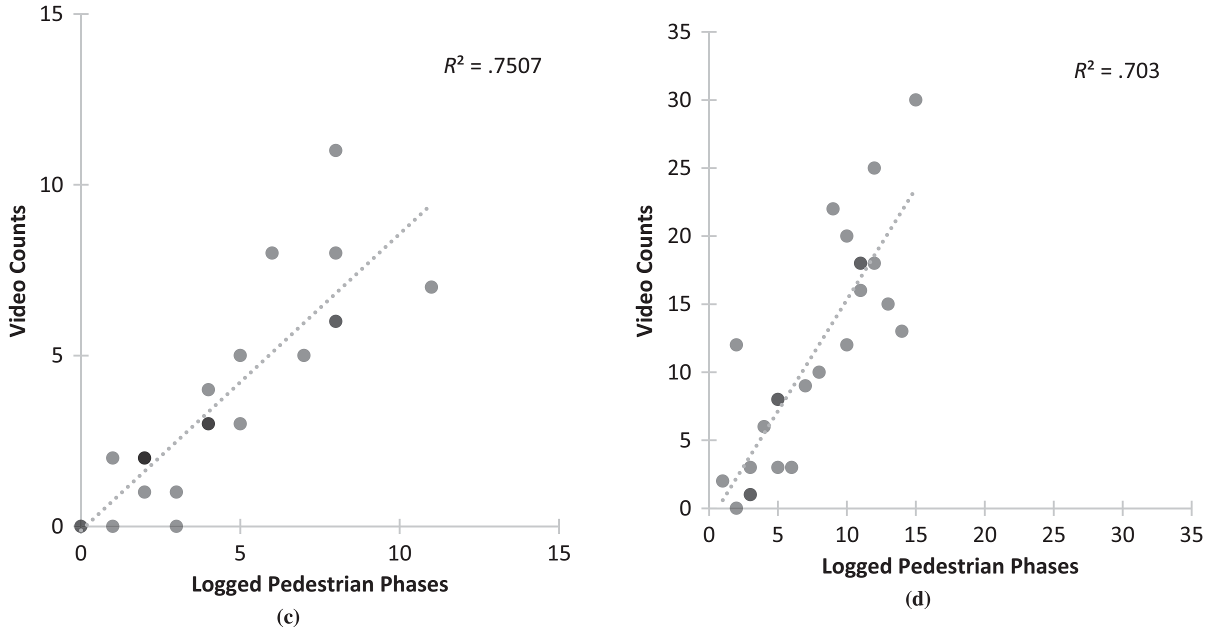

FIGURE 6 *(continued)* Scatter plots of hourly video counts versus hourly logged pedestrian phases: (*c*) east crosswalk and (*d*) west crosswalk (darker points = multiple observations).

those counted in the video, as quantified in the list below. Percentage of error was calculated using the following equation:

$$\%\ \text{error} = \frac{2070\ \text{loop count} - \text{video count}}{\text{video count}}$$

Errors by approach are estimated as follows:

Northbound: 1,474%,
Southbound: 1,169%,
Eastbound: 5,413%,
Westbound: 2,193%, and
Total: 2,180%.

The degree to which the inductive loops overcounted was significantly greater on the eastbound (OR-99W) approach. It is likely that this high error is caused by the location of the inductive loop on the roadway. The loop is installed close the right-turn pocket and consequently is counting a high number of right-turning vehicles. The eastbound loop is depicted in Figure 8 with a pickup truck driving within close proximity of the loop as it makes a right-turning movement.

To lend validity to the hypothesis that vehicles were being detected by the bicycle inductive loop on the eastbound 99W approach at the right-turn pocket, a scatter plot (Figure 9) was constructed to compare the bike volumes reported by the 2070 controller and the right-most lane vehicle volumes. A linear regression model was estimated using right-turning vehicle volumes as the independent variable and the eastbound bicycle volume (both as detected by the respective

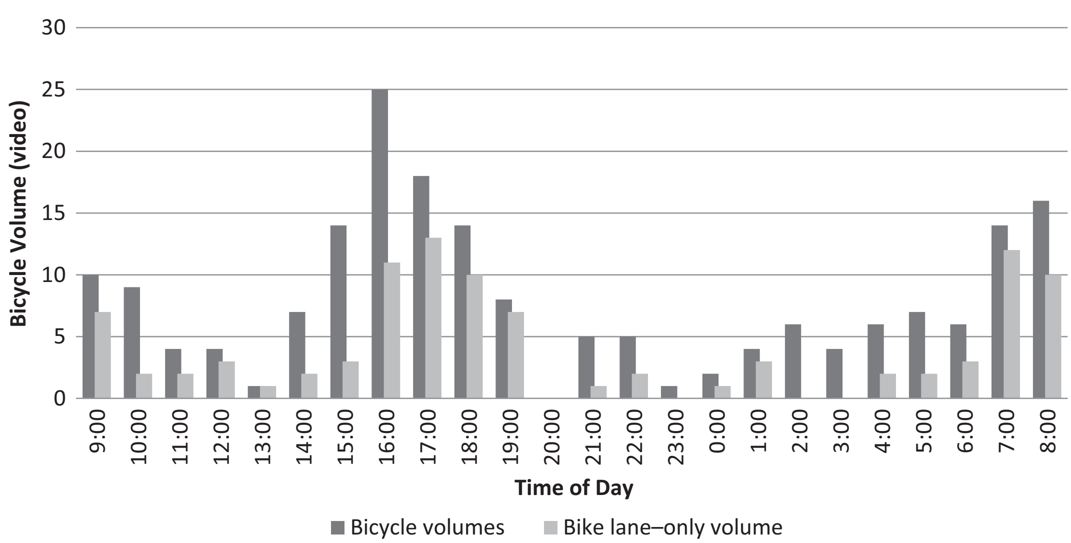

FIGURE 7 Hourly bicycle volumes (as counted from video) over pilot study period.

FIGURE 8 OR-99W eastbound approach toward Portland (see location of inductive loop relative to right-turning vehicle within dashed oval).

inductive loops). The regression model had a high R^2 value of .886, which suggests a clear linear relationship between the detections by the right-turning vehicle loop and the detections by the eastbound bicycle loop.

It is likely that loop shape, sensitivity, and location all played a role in the unintended detection of motor vehicles by the inductive loop purposed for counting bicycles. A diamond loop shape was installed at this intersection, which does not have as wide of a field of sensitivity as other loop configurations (as discussed in further detail in the section on lessons learned). As a default, the sensitivity of most loop detectors may be too low, as explained below:

> The sensitivity of the loop system is critical. Loop system sensitivity is defined as the smallest change of inductance at the electronics unit terminals that will cause the controller to activate. Many states specify that the electronics unit must respond to a 0.02 percent change in inductance, and typically many departments of transportation (DOTs) set the sensitivity setting at 4 or even lower by observing the flow of traffic and turning the sensitivity down until they stop getting detections and then turning it up a notch. (Note: On digital detectors with alphanumeric readouts, the scale typically goes from 1 to 10.) If no bicycles or motorcycles have gone by, inadvertently they might set the sensitivity too low. (*7*)

Bicycles have a significantly smaller mass of ferrous metal with which to trigger inductive loops, and thus it is difficult to determine a sensitivity setting that will be sensitive enough to detect all types of bicycles without being too sensitive so that nearby vehicles are inadvertently detected. However, as demonstrated by Kothuri et al., bicycles have been counted with relatively consistent accuracy using loops in the bike lane, so the results at this location are site specific (*6*). The project budget did not allow for loop rewiring or purchase of advanced loop cards that might better distinguish bicycles.

To test the effect of loop sensitivity, a shorter count (10 h) was conducted October 24, 2013. The sensitivity of the loop was lowered (so as to detect fewer automobiles in close proximity), and accuracy generally improved, with northbound error decreasing from 1,474% to 7%, southbound error decreasing from 1,169% to 89%, and westbound error decreasing from 2,193% to 61%. However, the issue with the eastbound loop location still persisted, as accuracy improved markedly less (from 5,413% to 2,430%) than with other loops. Both sensitivity settings and installation location play a critical role in inductive loop accuracy in counting bicycles.

Another issue that prevented accurate counting using the loop configuration tested was the fact that for the southbound and northbound bicycle traffic the approach and stop bar loops were wired in series (their primary purpose was presence detection for signal operation) such that counts on the approach loop cannot be separated from detection at the stop bar. Counts should be collected using approach loops, since detections of flowing traffic are more accurate than detections of stopped traffic.

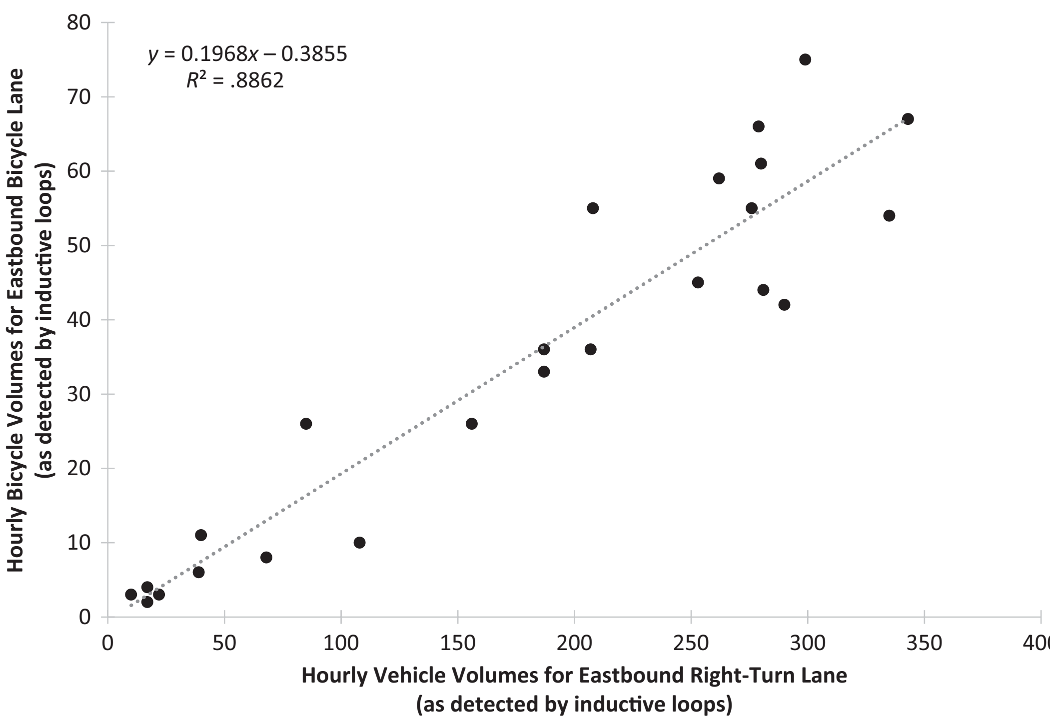

FIGURE 9 Eastbound bicycle volumes versus eastbound right-turning vehicle volumes (OR-99W).

SAMPLE APPLICATION

This section presents an example (applied to the pilot study intersection) of how the pedestrian phase logs in combination with a short-term count could be used to produce pedestrian annual average daily traffic (AADT) estimates. This procedure can inform further research into this data collection method as well as trial applications by transportation agencies. However, the factors developed are specific for this intersection on a specific day and should not be applied to other pedestrian phase log data.

Long-Term Traffic Patterns

The average pedestrian traffic patterns throughout the year of 2012 are outlined in this section. The monthly variation in the number of pedestrian phases is shown in Figure 10*a.* The phase counts are consistent, with at least 400 phases on average per day. Hourly average pedestrian phases granted at this intersection also follow a consistent daily trend throughout the year, as illustrated in Figure 10*b.* Most pedestrian phases take place around midday and decrease gradually during the afternoon. There are no other peak hours. This trend reflects a noncommute pattern. Figure 10*c* displays the average day-of-the-week pedestrian phases granted. Numbers are consistent throughout the week, with greater separation illustrated when comparing between months of the year. The bicycle traffic trends were also studied but because of problems with the count accuracy, as detailed in a prior section, graphs of the bicycle traffic trends are not shown.

Annual Average Daily Pedestrian Count Estimation

Procedures similar to estimating vehicle AADT from short-term vehicle counts were used in extrapolating short-term pedestrian counts to pedestrian AADT. The presented results of the data collection at OR-99W and Hall Boulevard suggest that pedestrian phases could be used to estimate average pedestrian volumes and pedestrian AADT. Further research and data collection are necessary to estimate this level of accuracy. The steps to estimate pedestrian AADT are described below by using 2012 pedestrian phase counts at OR-99W and Hall Boulevard.

In this case, because phases are being counted (instead of pedestrians), before estimating pedestrian AADT it is necessary to estimate average annual daily (pedestrian) phases (AADP). AADP is calculated by averaging the averages of the day-of-the-week counts or by averaging the averages of the day-of-the-month counts. The 2012 AADP value is 529 (see Table 2, Row 1), which is equivalent to, on average, almost 22 pedestrian phases granted per hour for all four crosswalks at the intersection. To put this number in context, if the cycle length is 2 min, there are 30 cycles per hour and up to 60 pedestrian phases per hour; per cycle there can be one pedestrian phase for northbound and southbound crossings and another pedestrian phase for eastbound and westbound crossings.

Each day-of-the-week count is the average of the count for each day of the week in the month. For example, all Mondays in January are averaged to compute the daily Monday average for January of 582 pedestrian phases granted. Table 2 shows average weekday and weekend actuations by month and day-of-the-week and day-of-the-month factors. Weekend AADP (476) is approximately 12% less than weekday AADP (550), which suggests that there may be slightly more utilitarian trips and activity at this particular intersection.

Pedestrian phase factors have been obtained by dividing each entry in the phase count table by the corresponding AADP value. These factors could be used to estimate the AADP value for that intersection if the pedestrian phase count on a particular day at that intersection is known. The days that best represent AADP are Tuesdays and Thursdays; the months that best represent AADP are March, July, and September (i.e., when the factors that are close to one).

To account for the fact that pedestrian phases are being counted, not actual pedestrians, an additional adjustment factor could be used. As calculated in Table 1, this adjustment factor is the ratio of the actual pedestrian volume to the number of pedestrian phases recorded by the Model 2070 controller. For the 24-h pilot study, the average ratio of pedestrians to actuations for all crosswalks was 1.24. However, this factor was created with data from only 1 day and it is not clear whether it is representative of the pedestrian-to-pedestrian phase ratio for the rest of the year. But as an example, given a short-term count of 482 pedestrians on a Thursday in August, pedestrian AADT calculation can precede as follows (using the estimated factor for Thursday in August that is 0.79):

$$\text{pedestrian AADT} = 0.79 \times 482 \times 1.24 = 472$$

Applying these particular factors to pedestrian phase counts at other intersections requires two critical assumptions:

1. Pedestrian travel patterns by day of week and month of year match those of the other intersection (if the AADP factors calculated above are applied) and
2. Adjustment factor to convert from pedestrian phases to actual pedestrians is generalizable to the rest of the year and to other 2070 intersections (if the 1.24 factor is applied).

As mentioned, further research and data analysis are necessary to test the validity of these assumptions. It is crucial that data from additional days throughout the year are used to better estimate the average ratio of pedestrians to actuations factor (e.g., one additional day in November, February, and May to include seasonal effects that are not present in the August data). In addition, a number of site-specific issues are likely to influence the calculated ratios:

- The surrounding land use and demographics will generally dictate pedestrian activity levels, particularly group size. When converting actuations to pedestrians, group size will affect pedestrian volume estimations from pedestrian actuation counts. For this method to applied, these land use, group size, and actuation factors would need to be developed.
- Site geometry or preferred pedestrian paths could result in higher frequency of multiple movements per pedestrian (i.e., the utilization of two crosswalks), which may increase the adjustment factor for the pedestrian–phase ratio.
- Pedestrians pushing buttons for multiple directions at the same corner can bias counts. In addition, bicyclists may also be using pedestrian push buttons (which was observed in the video).

As a result of specific characteristics and temporal variations in pedestrian travel activity, it is critical that agencies considering the use of pedestrian phase counts to estimate travel activity conduct their own site studies to calibrate the factors used. More research is needed at additional sites to estimate how weather, land use, sociodemographic

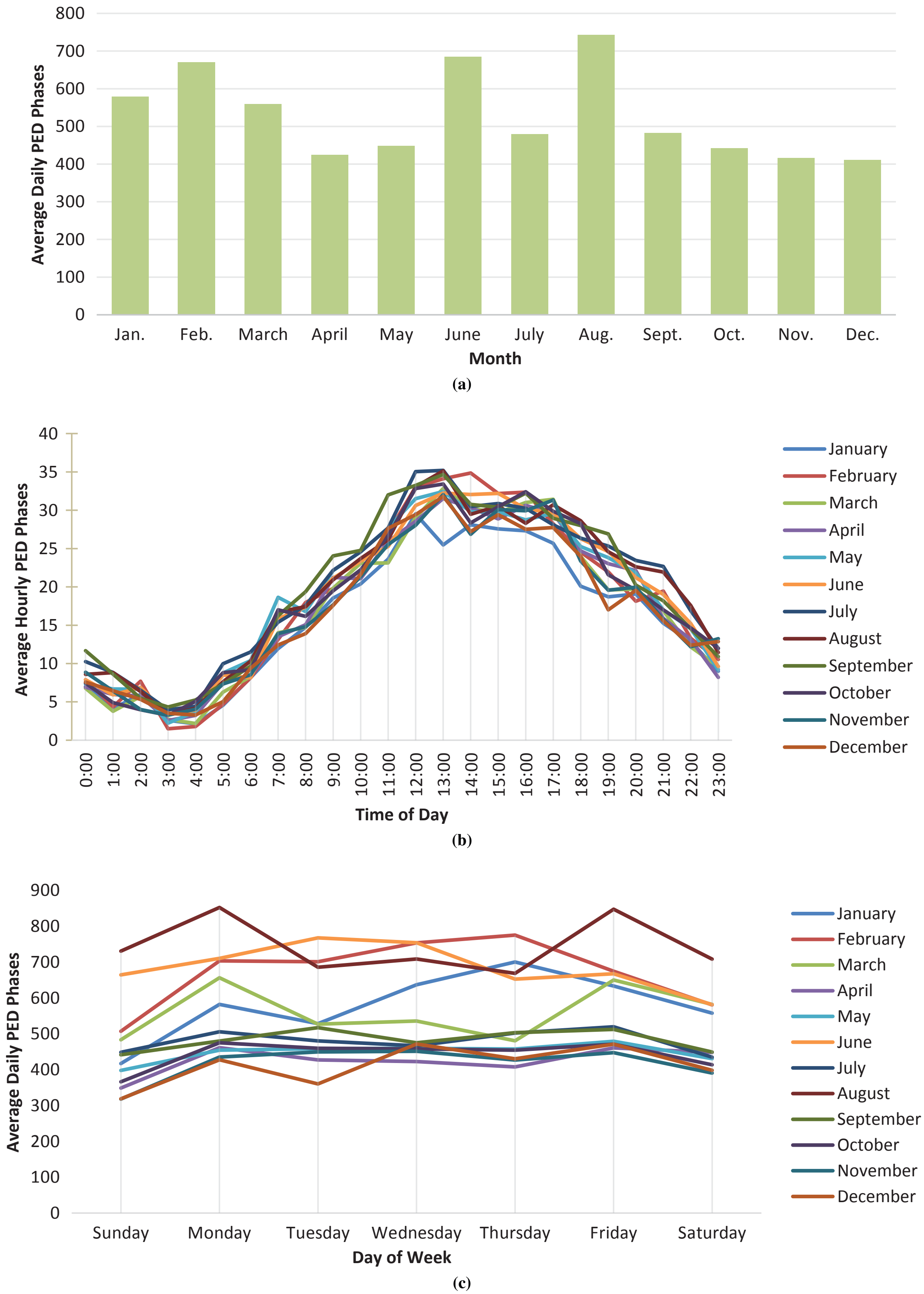

FIGURE 10 Summary charts of pedestrian phases logged in 2012 for pilot study intersection (OR-99W and Hall Boulevard, Tigard): (*a*) average daily pedestrian phases logged by month; (*b*) average hourly pedestrian phases logged, stratified by month; and (*c*) average day-of-week pedestrian phases logged, stratified by month.

TABLE 2 OR-99W and Hall Boulevard 2012 Day-of-Week and Monthly AADP

Daily Average	Value, by Month: Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	DOW Average	DOW Factors
Sunday	417	507	483	349	398	665	448	731	442	366	318	319	453	na
Monday	582	704	656	461	454	710	506	852	480	475	435	428	562	na
Tuesday	528	701	527	427	458	768	480	686	517	460	450	360	530	na
Wednesday	637	754	536	423	460	754	467	709	475	458	451	472	549	na
Thursday	700	775	480	408	458	653	502	668	503	454	427	430	538	na
Friday	634	675	650	461	479	667	520	847	512	471	447	471	569	na
Saturday	558	581	582	448	431	581	435	708	449	414	391	398	498	na
Monthly average	579	671	559	425	448	685	480	743	483	443	417	411	529 AADP	na
DOW Factors														
Sunday	1.27	1.04	1.09	1.52	1.33	0.80	1.18	0.72	1.20	1.44	1.66	1.66	na	1.17
Monday	0.91	0.75	0.81	1.15	1.16	0.74	1.05	0.62	1.10	1.11	1.21	1.24	na	0.94
Tuesday	1.00	0.75	1.00	1.24	1.15	0.69	1.10	0.77	1.02	1.15	1.18	1.47	na	1.00
Wednesday	0.83	0.70	0.99	1.25	1.15	0.70	1.13	0.75	1.11	1.15	1.17	1.12	na	0.96
Thursday	0.75	0.68	1.10	1.30	1.16	0.81	1.05	0.79	1.05	1.16	1.24	1.23	na	0.98
Friday	0.83	0.78	0.81	1.15	1.10	0.79	1.02	0.62	1.03	1.12	1.18	1.12	na	0.93
Saturday	0.95	0.91	0.91	1.18	1.23	0.91	1.22	0.75	1.18	1.28	1.35	1.33	na	1.06
DOM factors	0.91	0.79	0.95	1.24	1.18	0.77	1.10	0.71	1.10	1.19	1.27	1.29	na	1.00

NOTE: DOW = day of week; DOM = day of month; na = not applicable.

variables, and roadway characteristics affect the estimation of average ratio of pedestrians to actuations factor.

LESSONS LEARNED

The results of this pilot evaluation suggest several lessons or issues to be considered in using this approach.

Pedestrians

1. Phase logging will work best if push buttons are present (and working) and each pedestrian crossing has its own phase. If one crossing is on recall, the controller will log this service regardless of pedestrian activity, so this method of count estimation could not be used. Similarly, if the intersection has high pedestrian traffic such that every pedestrian phase is actuated during peak hour, the method is not appropriate, but such conditions are usually treated by setting the crossing to recall.
2. When a pedestrian pushes two different buttons for two directions (two different crosswalks) at the same corner, this action causes the controller to grant and log two phases (one in each direction). If only one pedestrian uses the intersection at this time, then the number of phases logged is overestimating the number of pedestrians.
3. The data may be biased depending on pedestrian group sizes. A controller grants and records one phase regardless of the number of pedestrians crossing during a phase. Every time a group of multiple pedestrians uses a crosswalk, the number of phases is underestimating the number of pedestrians.
4. In some instances, bicyclists push the pedestrian buttons, which can also introduce bias into the data (overestimation of pedestrians and underestimation of bicyclists); although this behavior was observed during the field study, the overall percentage of bicyclists pushing pedestrian buttons was less than 3% of the bicycle counts.

Bicycles

1. Loops should be installed at locations where vehicles will not be as likely to be inadvertently detected.
2. There are several loop configurations, such as quadrupole, diagonal quadrupole, chevrons, elongated diamond patterns, and rectangular. Quadrupole and parallelogram loop configurations have been found to correctly detect bicyclists. In California, Type D inductive loops are recommended for bicycle detection (*8, 9*). Portland, Oregon's inductive loops have been shown to count bicyclists (*6*). The authors of this report are also testing the accuracy of the city of Portland's inductive loops and have found that the loops have fewer errors than the loops used at OR-99W and Hall Boulevard (less than 20% error); however, the Portland bicycle loops tend to undercount cyclists.
3. The sensitivity of each loop must be calibrated to the lowest possible sensitivity that will still be sensitive enough to consistently detect bicycles. This sensitivity should be determined for each loop using at least one test bicycle, and bicycle detectability should be checked periodically to ensure long-term bicycle loop count accuracies.
4. Some investigation of sidewalk riding should be done. In this study, 49% of the observed cyclists used the sidewalk. This number is clearly a site-specific value but will likely depend on the location of loops, land use, perceived safety of the bicycle facilities, and the experience or comfort level of the cyclists using the intersection.
5. Although expensive and time consuming, video validation, or quality assurance/quality control, should always be conducted when inductive loops are to be used for bicycle volume counts. Without

video validation, it is impossible to assess how accurately the loops are counting bicycles. In addition, the behavior of cyclists can be only understood by evaluating video (e.g., sidewalk utilization).

6. Loops used for counting should be wired separately, not in series with other loops.

CONCLUSIONS

Results of a pilot study to evaluate the feasibility of pedestrian and bicycle counting technologies on a typical signalized intersection (under state DOT jurisdiction) were presented. The results indicate that logging pedestrian phases using signal controllers may be a cost-effective method to estimate pedestrian activity. Data validation through video counting proved valuable to understand the sources of errors and pedestrian and bicycle behavior at the intersection; for example, almost 50% of the bicyclists used the sidewalk and some of them used the pedestrian buttons.

The results were inconclusive on the feasibility of inductive loops for bicycle counting, but nonetheless revealed important lessons to be taken into account if inductive loops are to be used. The proper location of bicycle loops in relation to motorized traffic trajectories is essential. Devising methods and standards to properly calibrate bicycle loop inductance is also necessary.

The number of pedestrians and bicycles using this highly trafficked and congested suburban intersection was something that caught the attention of the Oregon DOT staff. There were no bicycle and pedestrian count data in this area before this study and counting over 500 pedestrians in a 24-h period was surprising; prior estimates were significantly lower. This result highlights the importance of statewide (as many locations as possible) counting stations that can provide a reasonable estimate of the level of pedestrian and bicycle activity.

ACKNOWLEDGMENTS

The research team acknowledges the Oregon Department of Transportation for funding this project. The authors thank all members of the Technical Advisory Committee for their comments and support: Lynn Cornell, Sheila Lyons, Sue Geniesse, Gary Obery, Julie Yip, Steve Lindland (Oregon DOT), and Bruce Moody (FHWA). The authors also acknowledge the support of Tiffany Slauter for providing access to Model 2070 controller data, Don Crownover for providing access to tube detector and video data, and Jessica Horning for sharing bicycle and pedestrian data sources. The authors thank Rodger Geller of the Portland Bureau of Transportation and Sirisha Kothuri of Portland State University for sharing their knowledge and bicycle data. The authors are also grateful to John Mermin, Deena Platman, Mel Huie, and Robert Spurlock for sharing Metro's nonmotorized data collection methods and continuous count data.

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The Standing Committee on Highway Traffic Monitoring peer-reviewed this paper.