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Pedestrian Counting Methods at Intersections: a Comparative Study

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Resources for implementing countermeasures to reduce pedestrian collisions in urban centers are usually allocated on the basis of need, which is determined by risk studies. They commonly rely on pedestrian volumes at intersections. The methods used to estimate pedestrian volumes include direct counts and surveys, but few studies have addressed the accuracy of these methods. This paper investigates the accuracy of three common counting methods: manual counts using sheets, manual counts using clickers, and manual counts using video cameras. The counts took place in San Francisco. For the analysis, the video image counts, with recordings made at the same time as the clicker and sheet counts, were assumed to represent actual pedestrian volume. The results indicate that manual counts with either sheets or clickers systematically underestimated pedestrian volumes. The error rates range from 8-25%. Additionally, the error rate was greater at the beginning and end of the observation period, possibly resulting from the observer's lack of familiarity with the tasks or fatigue.

Pedestrian Counting Methods at Intersections: a Comparative Study

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ABSTRACT
Resources for implementing countermeasures to reduce pedestrian collisions in urban centers are usually allocated on the basis of need, which is determined by risk studies. They commonly rely on pedestrian volumes at intersections. The methods used to estimate pedestrian volumes include direct counts and surveys, but few studies have addressed the accuracy of these methods. This paper investigates the accuracy of three common counting methods: manual counts using sheets, manual counts using clickers, and manual counts using video cameras. The counts took place in San Francisco. For the analysis, the video image counts, with recordings made at the same time as the clicker and sheet counts, were assumed to represent actual pedestrian volume. The results indicate that manual counts with either sheets or clickers systematically underestimated pedestrian volumes. The error rates range from 8-25%. Additionally, the error rate was greater at the beginning and end of the observation period, possibly resulting from the observer's lack of familiarity with the tasks or fatigue.

INTRODUCTION

Road collisions are a major public health concern throughout the world. It is estimated that 1.2 million traffic fatalities occur each year worldwide. The problem is especially acute for pedestrians, who face a significantly greater risk of death when involved in traffic collisions than do vehicle occupants *(1)*. Significant resources are focused on countermeasures that aim to reduce the risk of pedestrian injury. Because resources are limited, risk analysis is necessary to develop cost-effective countermeasures *(2)*.

Risk is defined as the frequency of an undesired event or collision per unit of exposure. Pedestrian volume is the exposure measure most frequently used in risk analysis. According to Gårder *(3)* pedestrian risk is closely correlated with pedestrian volume, more so than vehicle volumes. Although many state, regional, and local agencies have developed methodologies to collect pedestrian volume data, there is no consensus on which method is best *(4, 5)*. To improve the risk monitoring process, it is necessary to define a systematic pedestrian counting method.

The two most frequent types of pedestrian counting methods are direct counts and surveys. Direct counts involve direct observation of pedestrian activity at fixed locations, such as crosswalks or intersections. Surveys indirectly capture pedestrian activity in a geographic area by gathering travel data from a sample *(6)*.

Pedestrian volumes at intersections are usually collected directly using either (i) manual counts, taken by collectors in the field, or (ii) automated counts using specialized equipment. Although motorized vehicles are commonly counted with automated devices, the technology for counting non-motorized modes of transportation, especially pedestrians, is not very developed *(7)*.

The accuracy of these counting methods directly affects the accuracy of the exposure estimate and thus the value of the risk analysis at an intersection. However, few studies have attempted to compare the accuracy of different counting methods. This paper aims to compare the accuracy of three common pedestrian counting methods: (i) manual counts using sheets; (ii) manual counts using clickers; and (iii) manual counts using video cameras.

METHODS

The research was conducted at 10 different intersections in the city of San Francisco, California, during the last two weeks of April and the first week of May, 2006. Field observers collected pedestrian counts with either sheets or manual clickers. Counts were taken for four hours between 1:00 pm and 6:00 pm, with a break of one hour. Video footage of the intersection was recorded simultaneously with the field counts.

Two persons were contracted from a private consulting firm specializing in data collection. One individual made the field observations, and the other operated the video recorder. The contracted staff was the same for all data collection. Sheets were used at eight intersections and clickers at two intersections. The selected intersections had different pedestrian flows, with values varying between 12 and 262 pedestrian crossings per hour based on the video analyses, as shown in Table 1. Figures 1 and 2 present the camera angles used at two of the study intersections.

Before the start of data collection, the researchers supplied the field staff with the following directions:

1. The data collection must be synchronized with the video. The person collecting the data should begin to count the pedestrians when the video begins to run. During the period that the tape is being changed, the observer should stop counting.
2. The field observer must note any problem or interruption in the data collection, such as a break or lack of attention for any reason. These interruptions are important since the main objective was to compare the accuracy of the methods.
3. The field observer must count only pedestrians who cross the street centerline (e.g. the middle of the crossing). He or she should not count bicyclists unless they are walking their bicycle across the intersection.
4. The field observer must stand close to the crosswalk.

TABLE 1 Data Collection Schedule and Pedestrian Flow

Intersection	Date	Method	Volume (ped)	Period (hours)	Flow (ped/hour)
France and Mission St.	04/17/2006	Manual with sheets	128	4	32
Admiral Ave. and Mission St.	04/18/2006	Manual with sheets	49	4	12
16th St. and Capp	04/19/2006	Manual with sheets	412	4	103
Geneva and Mission St.	04/20/2006	Manual with sheets	1046	4	262
Folson and 7th St.	04/21/2006	Manual with sheets	334	4	84
Harrison and 7th St.	04/24/2006	Manual with sheets	651	4	163
Market and Castro	04/25/2006	Manual with sheets	579	4	145
Market and Noe	04/26/2006	Manual with sheets	994	4	249
Harrison and 10th St.	05/03/2006	Manual with clickers	161	4	40
Santa Rosa and Mission St.	05/05/2006	Manual with clickers	338	4	85

FIGURE 1 Camera angle used at Admiral Ave. and Mission St.

FIGURE 2 Camera angle used at Market and Castro (still from video tape)

Field data were entered into a Microsoft Access 2000 database. For quality control, all database tables were compared with the original field data sheets.

Manual with sheets

The field observer received a sheet with three fields: (i) direction of travel; (ii) pedestrian gender; and (iii) age. The observer was instructed to use his best judgment to assign the pedestrian to one of seven age categories.

At the top of the sheet, the observer was instructed to write the following information: (i) name of the intersection; (ii) his/her name; (iii) date of the data collection; and (iv) period of the data collection (check box) – divided in periods of 30 minutes. The field observer was told to concentrate on accurately counting the number of pedestrians, even if it meant leaving gender and age fields blank in crowded intersections.

To improve the analysis, after the fourth day (April 20), the field observer was asked, when possible, to take note of any distinguishing characteristics that would allow an individual to be identified in the video, i.e., clothing color, hair color, parcels or suitcases, exact time, and so on. This information made it possible to determine when the field observer missed or over-counted pedestrians, and to determine whether the manual data collection was properly synchronized with the video.

Manual with clicker

On May 3 and May 5, the field staff collected pedestrian counts using a manual clicker. The observer clicked once for every pedestrian crossing the intersection, regardless of direction. At the end of every 10-minute period, the observer noted the count on the clicker on the data sheet provided.

Manual with Video

The intersections were videotaped using a camera set up on a flatbed truck parked opposite the crosswalk being studied. The camera recorded an image of the crosswalk at an angle that allowed both directions of pedestrian travel to be captured. Video tapes were replaced after each hour.

Researchers involved in the study carefully analyzed the video tapes in order to obtain the most reliable results possible. The researchers tried to identify each pedestrian counted by the field observer. This task was only possible for the days that the field observer noted individual pedestrian characteristics.

The tapes were viewed in variable time, and sometimes viewed more than once if the results were in doubt. On average, one hour of video tape required three hours of video analysis. During the analysis, the researchers paid attention to whether the field counts were synchronized with the videotape and looked for any discrepancies between the field observations and the video images.

DATA ANALYSIS

The purpose of the data analysis was to compare the accuracy of the methods. Because it was not possible to know the exact number of pedestrians on the roadway at any given time, inter-reliability between the methods was used as a proxy for accuracy. The counts derived from the video tapes were assumed to be closest to the actual pedestrian volume.

The comparison used the relative difference between the counts taken through each method to calculate the error:

$$Error = \frac{NPi - NPv}{NPv} \qquad (1)$$

where NP_i is the number of pedestrians counted in the field and NP_v is the number of pedestrians counted using the video images. The error was calculated for each interval of data collection (30 minutes for the sheets and 10 minutes for the clickers), as well as for the total number of pedestrians counted at each intersection.

Synchronization of the field counts and video taping was a major issue identified during the video analysis, despite the fact that field staff were directed to synchronize the counting methods. Sometimes the field observer began counting slightly before or after the video camera began recording. When this occurred, it was difficult to compare the counts obtained through each method. To improve the results of the comparison study, counts taken in periods when the field observer was not synchronized with the video were not included in the calculation of the intersection error.

Comparisons of the accuracy of pedestrian gender and age identification were also made, but not included in this paper. The researchers concluded that it was not possible to precisely identify the gender or age of the pedestrians from the video images because of low image resolution.

RESULTS

In the first week of data collection, the field observer did not follow all of the instructions he was given and did not consistently collect data for four-hour periods. For example, he sometimes started counting late; failed to take note of his breaks; and counted bicycles as pedestrians. Despite this, the video tapes were analyzed for the entire counting period (four hours) in order to determine the average hourly pedestrian volume (Table 1).

The results of the comparison reveal that the field observer systematically counted fewer pedestrians than were observed on the video recordings. The average error calculated for the manual counting using sheets was 15%, varying from 9% to 25%, as shown in Tables 2. For the manual counting with clickers, the average error was 11%, varying from 8% to 15% (Table 3). Given the variation in the results, it is not possible to determine which method, with sheets or clickers, is the most accurate.

TABLE 2 Comparison of Counting Methods (Video vs. Sheets)

Period	**Date**						
	4/17/2006	**4/18/2006**	**4/19/2006**	**4/20/2006**	**4/21/2006**	**4/24/2006**	**4/25/2006**
	Error	**Error**	**Error**	**Error**	**Error**	**Error**	**Error**
1:00 to 1:30	Not Counted	Not Counted	-27%	-28%	-16%	-7%	-22%
1:30 to 2:00	150%*	Not Counted	-18%	-6%	0%	-2%	-17%
2:00 to 2:30	-13%	0%	3%	-23%	-17%	-16%**	-29%
2:30 to 3:00	-14%	0%	-28%	-2%	-12%		-26%
4:00 to 4:30	-13%	-22%	-42%	-14%	-8%	-8%	-27%
4:30 to 5:00	-21%	86%*	-67%	-15%	-10%	-11%	-17%
5:00 to 5:30	Not Counted	Not Counted	-25%	-16%	-5%	-3%	-25%
5:30 to 6:00	Not Counted	Not Counted	-49%	3%	-8%	-10%	-31%
Error (Total)	**-15%**	**-11%**	**-21%**	**-12%**	**-10%**	**-9%**	**-25%**

* Not included in the total, because it was not synchronized with the video
**In this period, the field observer failed to record the counts in half hour periods

TABLE 3 Comparison of Counting Methods (Video vs. Clickers)

	5/3/2006						5/5/2006					
	1:00 to 2:00pm						1:00 to 2:00pm					
Error (10 min)	-11%	-43%	-13%	0%	0%	0%	0%	0%	-19%	17%	-8%	100%
Error (hour)	-11%						2%					
	2:00 to 3:00pm						2:00 to 3:00pm					
Error (10 min)	-25%	-67%	0%	100%	-50%	0%	0%	-14%	25%	-31%	-8%	9%
Error (hour)	-23%						-5%					
	4:00 to 5:00pm						4:00 to 5:00pm					
Error (10 min)	0%	17%	33%	-25%	-11%	0%	50%	-25%	-41%	-33%	-40%	-88%
Error (hour)	0%						-32%					
	5:00 to 6:00pm						5:00 to 6:00pm					
Error (10 min)	-20%	0%	38%	-33%	0%	20%	-30%	6%	-64%	-15%	-8%	-88%
Error (hour)	0%						-21%					
Error (4 hours)	**-8%**						**-15%**					

An in-depth analysis of the data revealed that error was often greater at the beginning and end of the data collection period. Possible explanations for this finding include: (i) the observer's lack of familiarity with the intersection and the counting method at the beginning of the data collection; (ii) the long counting periods, which may have caused the observer to become fatigued and lose attention; and (iii) lack of synchronization with the video that was not possible to identify.

It was assumed that the observer would have more difficulty counting at intersections with high volumes of pedestrians, increasing the error value. However the results revealed that pedestrian flow did not influence the error, since the correlation (R^2 =0.1) between them was weak. Figure 3 presents a graph with the relationship between the error and the pedestrian flow.

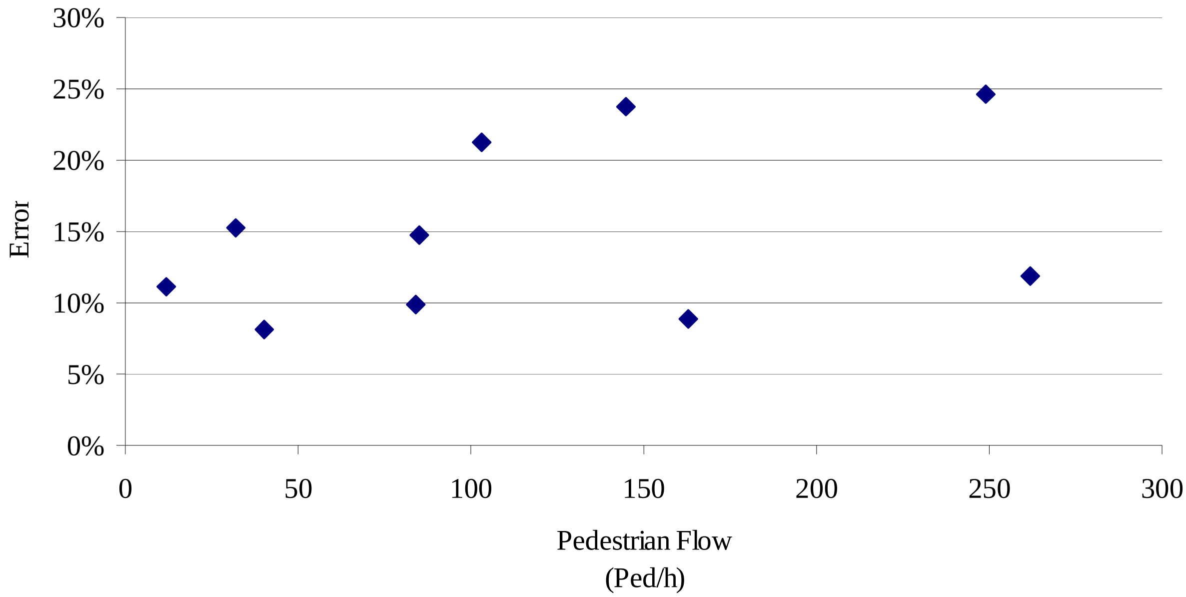

FIGURE 3 Relationship between the error and the pedestrian flow

DISCUSSION

The most significant results of this study were that pedestrian counts taken in the field were systematically lower than counts taken by observing video recordings, and that the accuracy of field counts did not seem to be strongly related to pedestrian flow. These results stem from the fact that the collection of field counts using either sheets or clickers is very difficult to control, and requires planning and organization during the counting day *(5)*.

The level of observer attention is one aspect of field data collection that is difficult to control. In this study, the observer may have become distracted at intersections with little pedestrian activity, but may have been more focused in areas with high activity that demanded his attention. It is also possible that the error was related to the observer's unique characteristics and motivation. Future studies should use multiple field observers to determine how the characteristics of the observers, such as their experience and background, affect the quality of the pedestrian counts. However, given the budgetary constraints of most transportation agencies, it may be difficult to ensure that field observers have high-level training and experience.

It was expected that manual counts taken with clickers would have very low error because this method allows the observer to keep his attention on the intersection and does not demand that he identify and record pedestrian characteristics. No significant difference was found in the relative accuracy of manual counts using clickers and manual counts using sheets; however, more research is needed to compare the methods.

Although this study suggests that field counts may be less accurate than counts taken with video images, it is often necessary to use field observers to record detailed pedestrian characteristics and behaviors. It is difficult to identify these characteristics on video recordings without adequate image resolution and a well-selected camera angle.

This study suggests that video recordings should be used in situations where the accuracy of the count is of primary importance. However, users of this method should be aware that obtaining an accurate count from video can be very time consuming and requires meticulous attention to the video analysis. Overall, the choice of pedestrian counting method depends on the data collection needs and available resources.

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