Developing a database for pedestrians’earthquake emergency evacuation in indoor scenarios

Junxue Zhou,Sha Li,Gaozhong Nie

Abstract

With the booming development of evacuation simulation software, developing an extensive database in indoor scenarios for evacuation models is imperative. In this paper, we conduct a qualitative and quantitative analysis on the collected videotapes and aim to provide a complete and unitary database of pedestrians' earthquake emergency response behaviors in indoor scenarios, including interactions between man and the environment. Using the qualitative analysis method, we extract keyword groups and keywords that code the response modes of pedestrians in indoor scenarios and construct a general decision flowchart using chronological organization. Using the quantitative analysis method, we analyze data on the delay time, evacuation speed, evacuation route and emergency exit choices. Furthermore, we study the effect of classroom layout on emergency evacuation. The database in indoor scenarios provides reliable input parameters and allows the construction of real and effective constraints for use in software and mathematical models. It can also be used to validate the accuracy of evacuation models.

Citation: Junxue Zhou,Sha Li,Gaozhong Nie Developing a database for pedestrians’earthquake emergency evacuation in indoor scenarios. **protocols.io**

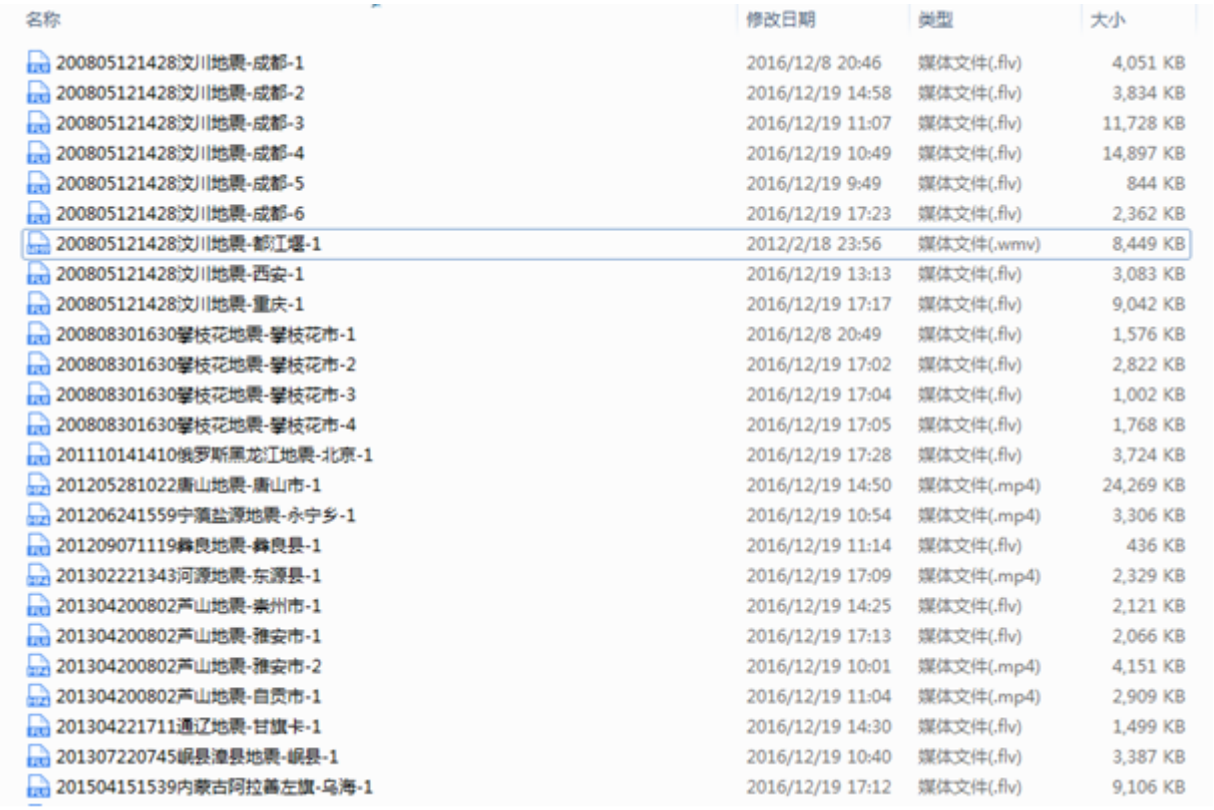
dx.doi.org/10.17504/protocols.io.mfxc3pn

Published: 04 Jan 2018

Protocol

Step 1.

We collect social surveillance video footage taken during real earthquakes in mainland China, and we select 30 surveillance videos from the collected videos as the study data. The 30 selected videos show more than one hundred individuals. In this paper, we describe a qualitative and quantitative analysis of the earthquake emergency response behavior of these more than one hundred individuals.

1. 

名称	修改日期	类型	大小
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200805121428汶川地震-成都-2	2016/12/19 14:58	媒体文件(.flv)	3,834 KB
200805121428汶川地震-成都-3	2016/12/19 11:07	媒体文件(.flv)	11,728 KB
200805121428汶川地震-成都-4	2016/12/19 10:49	媒体文件(.flv)	14,897 KB
200805121428汶川地震-成都-5	2016/12/19 9:49	媒体文件(.flv)	844 KB
200805121428汶川地震-成都-6	2016/12/19 17:23	媒体文件(.flv)	2,362 KB
200805121428汶川地震-都江堰-1	2012/2/18 23:56	媒体文件(.wmv)	8,449 KB
200805121428汶川地震-西安-1	2016/12/19 13:13	媒体文件(.flv)	3,083 KB
200805121428汶川地震-重庆-1	2016/12/19 17:17	媒体文件(.flv)	9,042 KB
200808301630攀枝花地震-攀枝花市-1	2016/12/8 20:49	媒体文件(.flv)	1,576 KB
200808301630攀枝花地震-攀枝花市-2	2016/12/19 17:02	媒体文件(.flv)	2,822 KB
200808301630攀枝花地震-攀枝花市-3	2016/12/19 17:04	媒体文件(.flv)	1,002 KB
200808301630攀枝花地震-攀枝花市-4	2016/12/19 17:05	媒体文件(.flv)	1,768 KB
201110141410俄罗斯黑龙江地震-北京-1	2016/12/19 17:28	媒体文件(.flv)	3,724 KB
201205281022唐山地震-唐山市-1	2016/12/19 14:50	媒体文件(.mp4)	24,269 KB
201206241559宁蒗盐源地震-永宁乡-1	2016/12/19 10:54	媒体文件(.mp4)	3,306 KB
201209071119彝良地震-彝良县-1	2016/12/19 11:14	媒体文件(.flv)	436 KB
201302221343河源地震-东源县-1	2016/12/19 17:09	媒体文件(.mp4)	2,329 KB
201304200802芦山地震-崇州市-1	2016/12/19 14:25	媒体文件(.flv)	2,121 KB
201304200802芦山地震-雅安市-1	2016/12/19 17:13	媒体文件(.flv)	2,066 KB
201304200802芦山地震-雅安市-2	2016/12/19 10:01	媒体文件(.mp4)	4,151 KB
201304200802芦山地震-自贡市-1	2016/12/19 11:04	媒体文件(.mp4)	2,909 KB
201304221711通辽地震-甘旗卡-1	2016/12/19 14:30	媒体文件(.flv)	1,499 KB
201307220745岷县漳县地震-岷县-1	2016/12/19 10:40	媒体文件(.flv)	3,387 KB
201504151539内蒙古阿拉善左旗-乌海-1	2016/12/19 17:12	媒体文件(.flv)	9,106 KB

Step 2.

The Transana software package (http://www.transana.org/) is used to analyze the earthquake response behaviors of these more than one hundred individuals. The personal characteristics of each individual, their pre-earthquake states and their responses during each earthquake are expressed in terms of keyword groups and keywords. Using the Transana software package, we calculate the frequency of each keyword. Furthermore, we analyze the relationships between the delay time before the first protective behavior is displayed and seismic intensity, gender, location and other factors.

To illustrate the use of the Transana software package, we select a surveillance video file (20150415 Inner Mongolia earthquake-Wuhai-2-1, which was taken at a supermarket belonging to the person shown in the video) as an example.

Transcript: 20150415 Inner Mongolia earthquake-Wuhai-2-1

Male, 40-50 years old, alone, in a supermarket, wearing a blue sweater

¤ (0:00:00.6) Sitting in a chair at the checkout counter of his supermarket and working

¤ (0:00:07.1) [Earthquake shaking begins]

¤ (0:00:07.1) He is not aware of the earthquake and continues performing his original work

¤ (0:00:08.3) He looks around and stops performing his original work

¤ (0:00:11.6) He leaves the room (evacuates)

¤ (0:00:14.9) He leaves the room and is not observable

¤ (0:00:47.2) [Earthquake shaking stops]

¤ (0:01:00.0) Observable

¤ (0:01:01.4) He returns room to collect his belongings

¤ (0:01:07.9) He takes his mobile phones and leaves the room again (evacuates)

The keywords in the transcript are as follows:

Individual characteristics: Male, 40-50 years old

Pre-earthquake state: In a supermarket, working, alone

Perception of the earthquake: Environmental trigger

First response: Continues performing his original work

First response: Looks around

First protective behavior: Evacuates

Subsequent protective behavior: Returns room to collect his belongings

Subsequent protective behavior: Evacuates

Step 3.

The Tracker software package (http://physlets.org/tracker/) is used to quantitatively analyze the earthquake evacuation behaviors of these more than one hundred individuals. This paper examines the relationship between evacuation speed and seismic intensity, location, gender, age and other factors. Furthermore, we construct a seismic intensity-location matrix of evacuation speed. In addition, the numerical values of evacuation speed under different seismic intensities and location conditions are obtained.

In this paper, we select a surveillance video file as an example to illustrate the use of Tracker software:

（1）Identify the frames you wish to analyze: Set the Start frame and End frame to define the range you wish to analyze; If the video contains too many frames to analyze (more than 20), increase the Step size to automatically skip frames.（**Fig.3A**）

（2）Calibrate the scale: Drag the ends of the calibration stick to a video feature with known length. Then click the readout to select it and enter the known length. In this example, the height of the classroom door is calibrated(2.04m)（**Fig.3B**）

（3）Set the reference frame origin and angle: Drag the origin and x-axis to set the reference frame origin and angle: A common choice for the origin is the initial position of an individual. The scale and reference frame origin and angle uniquely define the coordinate system used to convert pixel image positions to scaled world coordinates（**Fig.3C**）

4Track individuals with the mouse: When tracking an individual, mark his position on every Step size. And then, his speed and acceleration at that moment can be determined. Each individual in the video file is marked as a Point Mass with different colors and shapes and the point mass center is located at the individuals' shoulder level. In this example, the Step size is every two frames. Finally, individual's evacuation route is represented by a line marked with the same color as Point Mass **Fig.3D**

5Plot and analyze the tracksThe instantaneous speed and instantaneous acceleration of each individual at every moment are recorded, and Tracker software can display graphs of every individual's speed and acceleration. Two of the most powerful analysis options available from Tracker software are Analysis the track data and Function definition. In this example, the individual's average speed at his emergency evacuation process is 2.22m/s.

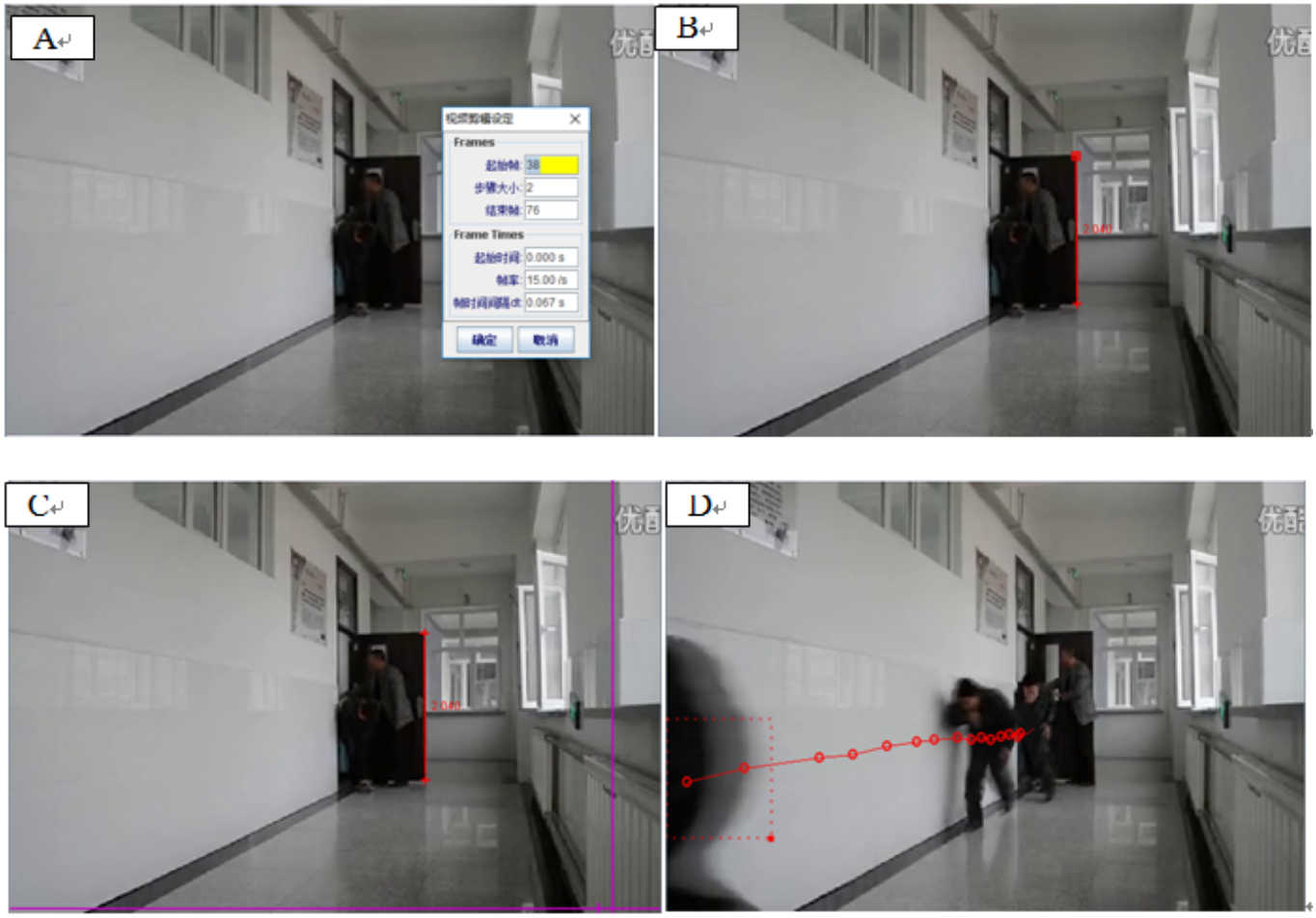
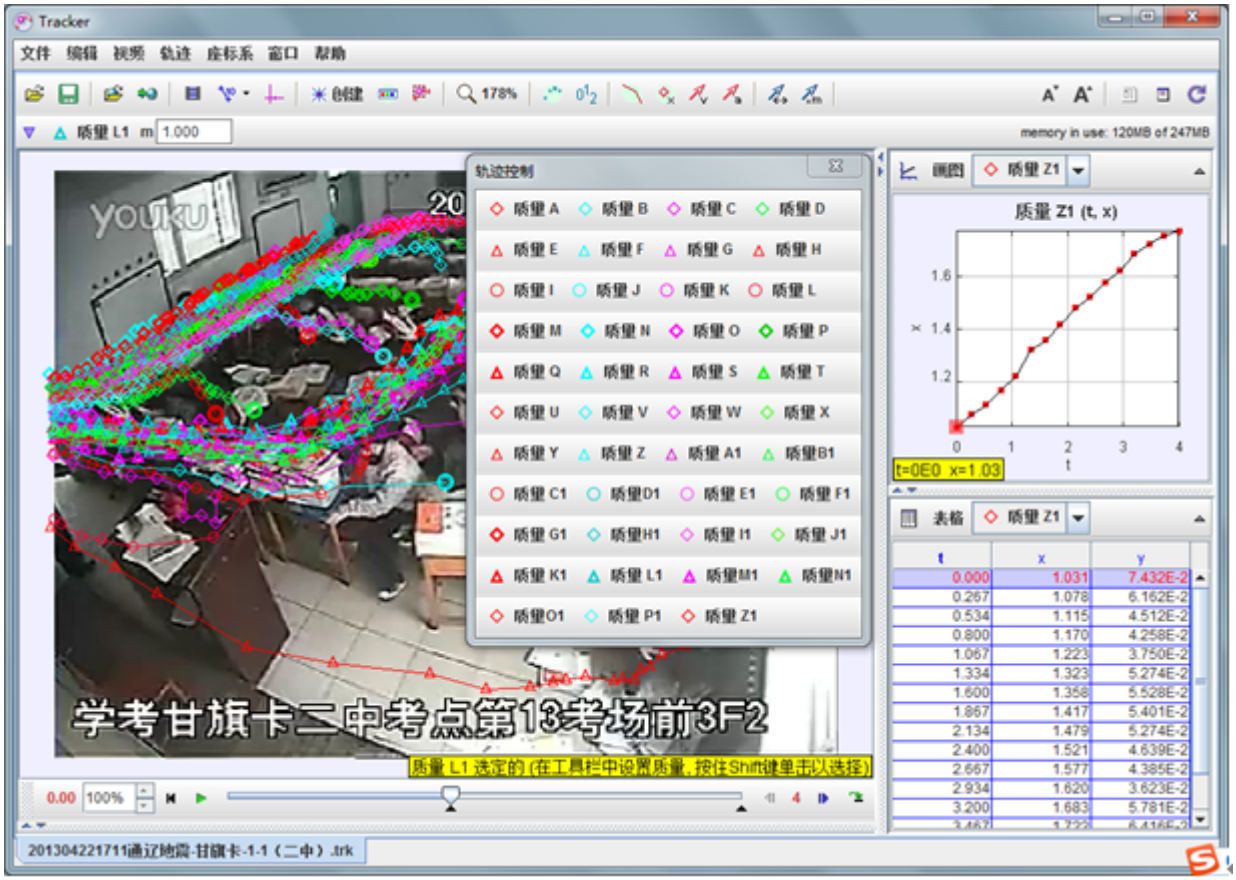
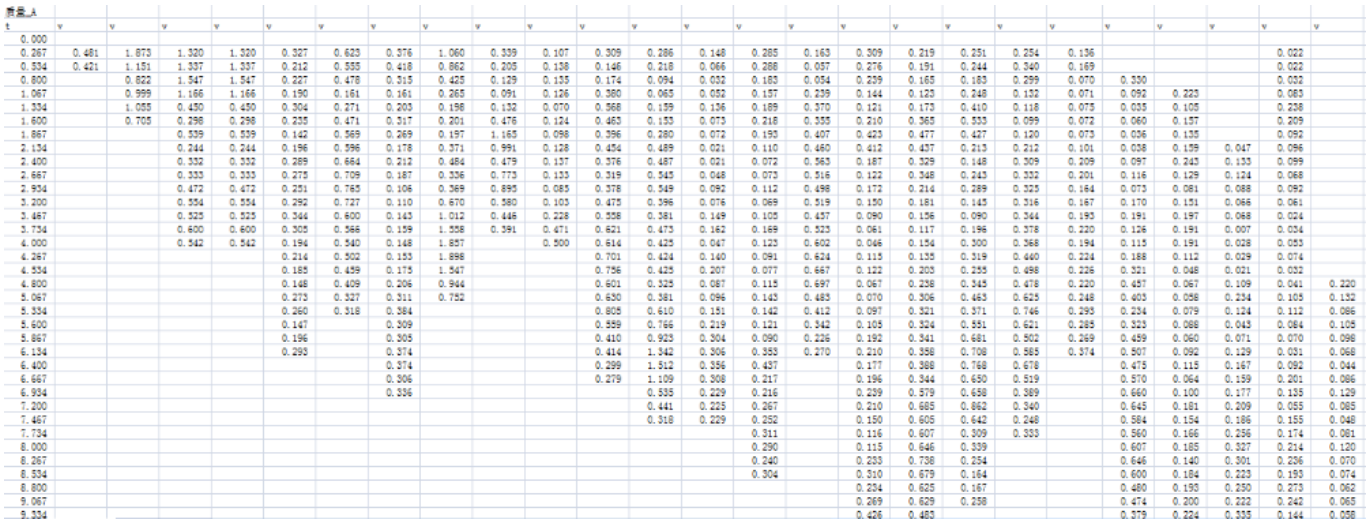


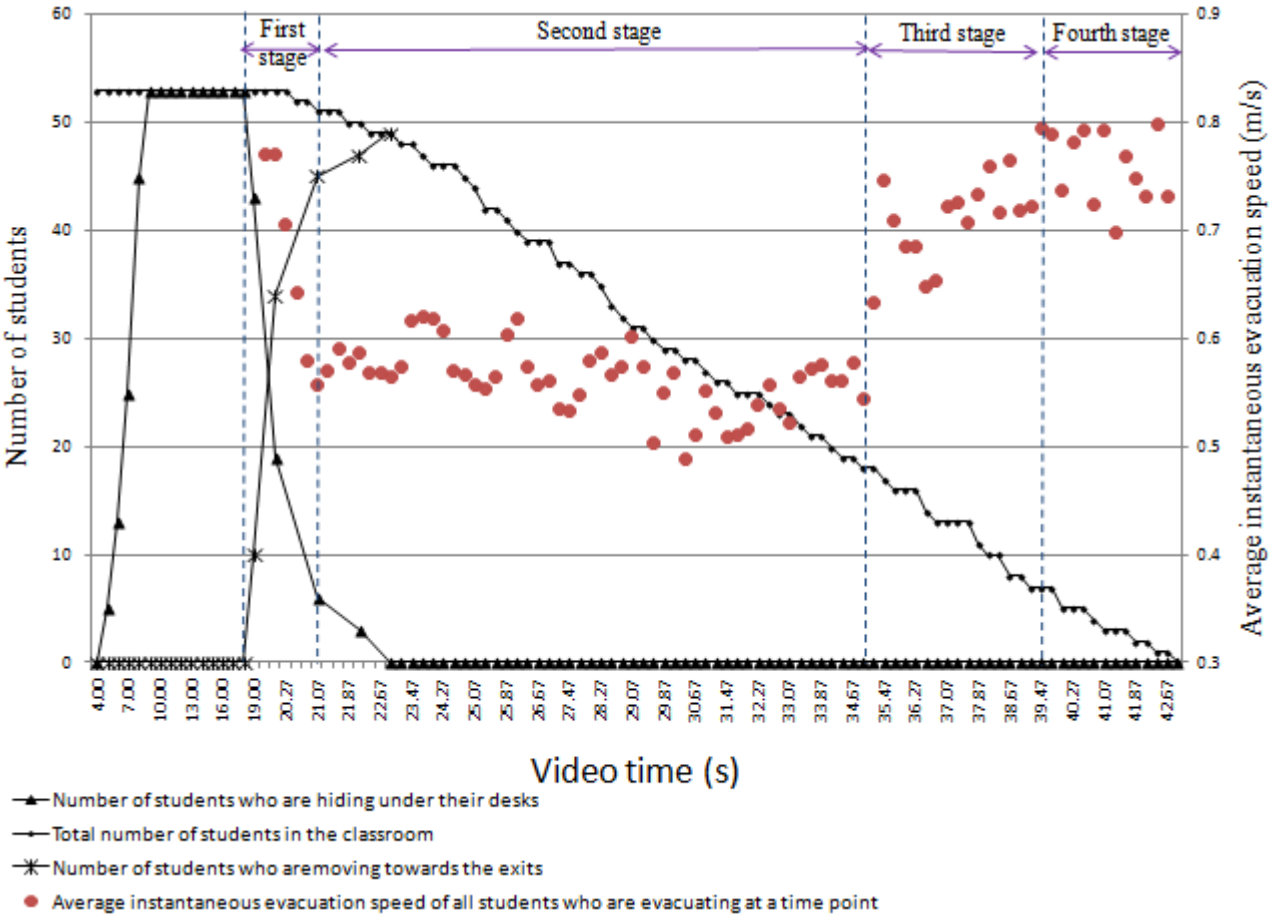
Fig.3 The use of Tracker software: A. Identify the frames you wish to analyze; B. Calibrate the scale; C. Set the reference frame origin and angle; D. Track individuals with the mouse



Step 4.

We analyze the evacuation routes chosen by students in a classroom in the No. 2 Middle School of Ganqika and calculate the average instantaneous evacuation speed of students at every moment during the earthquake evacuation process. In addition, the changes in average instantaneous evacuation speed in four different stages are analyzed.



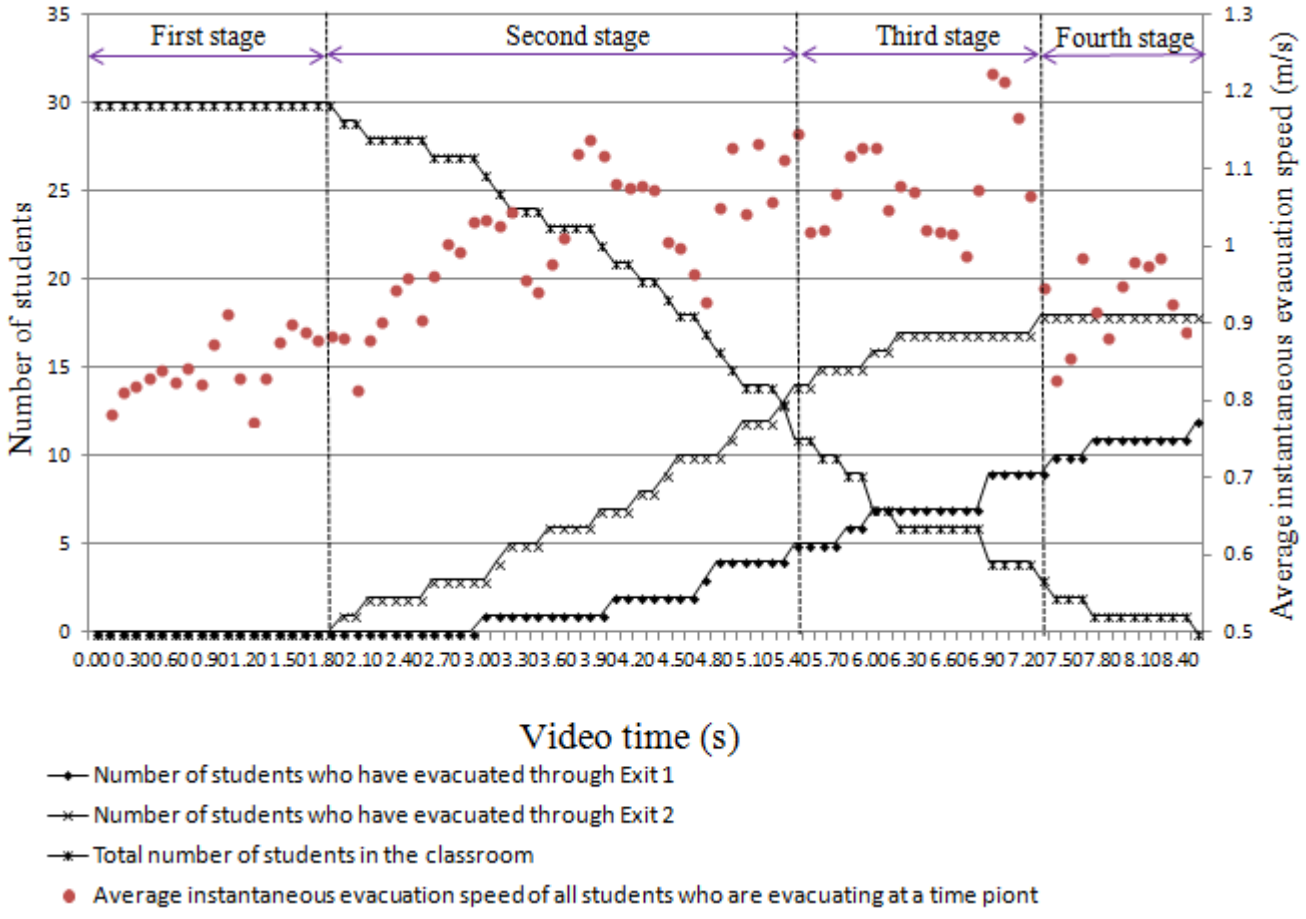


Step 5.

We analyze the emergency exit choices of students in Class 3 of Grade 7 in the Middle School of Tangshan Yucai and study the effects of evacuation guidance provided by teachers on the earthquake evacuation decisions made by students. By calculating the average instantaneous evacuation speed of students at every moment during the earthquake evacuation process, we also analyze the changes in average instantaneous evacuation speed in the four different stages.

质量_A

t	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v
0.000																				
0.100	0.364																			
0.200	0.325																			
0.300	0.345		1.136																	
0.400	0.516		1.322																	
0.500	0.608	0.581	1.020																	
0.600	0.405	0.521	0.318																	
0.700	0.359	0.356	0.365	0.254														0.636		
0.800	0.363	0.310	0.440	0.109			0.400								0.357			0.346		
0.900	0.276	0.324	0.311	0.627			0.393								0.611			0.324		
1.000	0.273	0.333	0.015	1.025			0.473								0.314	0.352		0.299		
1.100	0.279	0.318	0.031	0.635			0.561								0.156	0.433		0.145		
1.200	0.200	0.245	0.122	0.278			0.567								0.277	0.300		0.229		
1.300	0.122	0.300	0.540	0.254			0.502	0.279							0.378	0.280		0.189	0.356	
1.400	0.352	0.242	1.070	0.254			0.438	0.264	0.140						0.259	0.174	0.472	0.225	0.446	
1.500	0.478	0.171	0.998	0.357			0.412	0.330	0.215						0.218	0.296	0.354	0.307	0.447	
1.600	0.256	0.115	0.998	0.667			0.388	0.296	0.319						0.269	0.160	0.503	0.189	0.133	
1.700	0.161	0.162	0.762	0.566			0.413	0.384	0.368						0.088	0.160	0.697	0.349	0.217	
1.800	0.191	0.103	0.631	0.319			0.497	0.454	0.456						0.188	0.063	0.617	0.299	0.386	
1.900	0.299	0.174	0.600	0.287			0.534	0.325	0.473						0.298	0.238	0.379	0.223	0.029	
2.000	0.327	0.217	0.219	0.243			0.498	0.365	0.383						0.332	0.168	0.572	0.373	0.079	
2.100	0.283	0.162	0.936	0.436			0.534	0.371	0.378						0.310	0.244	0.580	0.400	0.103	
2.200	0.185	0.131	1.469	0.684			0.680	0.385	0.333						0.238	0.335	0.200	0.291	0.071	
2.300	0.191	0.159	1.094	1.056	0.380		0.629	0.386	0.282						0.319	0.301	0.274	0.331	0.028	
2.400	0.243	0.157	1.119	0.872	0.255		0.469	0.474	0.173						0.386	0.357	0.199	0.400	0.123	
2.500	0.313	0.250		0.549	0.383	0.431	0.521	0.416	0.081						0.329	0.672	0.200	0.200	0.112	
2.600	0.442	0.276		0.828	0.509	0.547	0.474	0.249	0.181	0.541					0.301	1.332	0.404	0.159	0.364	0.196
2.700	0.456	0.197		0.906	0.551	0.637	0.511	0.276	0.342	0.420					0.161	1.689	0.458	0.376	0.356	0.312
2.800	0.487	0.150		0.907	0.495	0.601	0.671	0.234	0.240	0.328					0.148	1.143	0.338	0.458	0.543	0.705
2.900	0.533	0.145		0.990	0.435	0.474	0.655	0.217	0.180	0.400					0.317	1.353	0.314	0.440	0.622	0.737
3.000	0.640	0.102		0.825	0.426	0.251	0.754	0.279	0.281	0.416					0.609	1.368	0.578	0.314	0.320	0.549
3.100	0.711	0.056		1.172	0.314	0.237	0.720	0.335	0.266	0.408	0.534				0.612		0.400	0.356	0.549	0.573
3.200	0.655	0.118		1.581	0.240	0.239	0.670	0.411	0.181	0.527	0.607				0.469		0.127	0.362	0.405	0.597	1.381
3.300	0.608	0.118		1.021	0.289	0.168	0.702	0.413	0.307	0.471	0.362				0.423		0.159		0.229	0.653	0.326
3.400	0.767	0.095		0.779	0.287	0.170	0.672	0.318	0.249	0.360	0.218				0.590		0.333		0.234	0.323	0.335
3.500	0.797	0.082		0.896	0.312	0.212	0.750	0.364	0.230	0.385	0.360				0.495		0.372		0.589	0.678	0.495



Step 6.

We compare the process of evacuation from the two classrooms in the schools of Tangshan and Ganqika and study the influence of classroom layout on the evacuation efficiency of the students.

时间-地震-地点-第几个人	性别	年	做什么	位置	是否与亲人朋友在一起	地震开始时刻	第一反应（开始时刻）	第一动作（开始时刻	第二动作（开始时刻）	第三动	震后反应
2012052810222唐山地震-唐山市-1-1	男	13	上课	教室	与同学一起	00：00（视频时间）	张望	抱头躲桌子下00：09	疏散00：56		出视频01：10
20130420080芦山地震-崇州市-1-3	女	20	家务	在家	与家人一起	00：06（视频时间）	继续原来的活动	疏散00：20	等家人00：52+疏散00：57		出视频00：48
20160731171谷稽地震-资州市-2-1	女	25	上班	超市	与同事一起	01：10（视频时间）	张望+与他人交流	疏散01：33			出视频01：58
20130420080芦山地震-崇州市-1-1	女	26	家务	在家	与家人一起	00：06（视频时间）	继续原来的活动	疏散00：23	返回拿财物00：24疏散00：31		出视频00：34
20160731171谷稽地震-林城县-1-1	男	31	看店	汽车修理厂	独自一人	00：00（视频时间）	继续原来的活动	疏散00：23	返回从事原先的工作00：30		出视频00：36
20130420080芦山地震-自贡市-1-1	女	36	上班	医院	和病人一起	00：15（视频时间）	继续原来的活动	提供帮助00：22	护送其他病人00：27		
20130420080芦山地震-自贡市-1-1	女	36	上班	医院	和病人一起	00：15（视频时间）	继续原来的活动	提供帮助00：22	护送其他病人00：27		
20130420080芦山地震-崇州市-1-2	男	40	家务	在家	与家人一起	00：06（视频时间）	继续原来的活动	疏散00：22			出视频00：48
20130420080芦山地震-崇州市-1-4	男	39	家务	在家	与家人一起	00：06（视频时间）	继续原来的活动	疏散00：22			出视频00：48
20130420080芦山地震-自贡市-1-2	女	50	上班	医院	和病人一起	00：15（视频时间）	继续原来的活动	继续工作00：21			
20130222213431河源地震-东源县-1-3	女	16	看店	超市	与家人一起	00：05（视频时间）	张望+与他人交流	继续工作00：25			
20111014141俄罗斯黑龙江地震-北京-1-1	男	25	看店	理发店	与同事一起	00：00（视频时间）	与他人交流	继续工作00：23			
20111014141俄罗斯黑龙江地震-北京-1-2	女	26	看店	理发店	与同事一起	00：00（视频时间）	与他人交流	继续工作00：23			
20111014141俄罗斯黑龙江地震-北京-1-3	男	30	看店	理发店	与同事一起	00：00（视频时间）	与他人交流	继续工作00：23			
20111014141俄罗斯黑龙江地震-北京-1-4	女	25	看店	理发店	与同事一起	00：00（视频时间）	与他人交流	继续工作00：23			
20130222213431河源地震-东源县-1-1	男	43	看店	超市	与家人一起	00：05（视频时间）	张望+与他人交流	继续工作00：25			出视频00：32
20130222213431河源地震-东源县-1-2	女	52	看店	超市	与家人一起	00：05（视频时间）	张望+与他人交流	继续工作00：25			出视频00：32
20080830163攀枝花地震-攀枝花市-1-3	男	6	看书	图书馆	与陌生人一起	00：03（视频时间）	张望	疏散00：08			出视频00：14
20080830163攀枝花地震-攀枝花市-1-7	男	6	看书	图书馆	与陌生人一起	00：37（视频时间）	张望	抱头躲桌子下00：44	疏散00：48		出视频00：51
20080830163攀枝花地震-攀枝花市-1-9	男	6	看书	图书馆	与陌生人一起	00：37（视频时间）	继续原来的活动	疏散00：39			出视频00：44
20080830163攀枝花地震-攀枝花市-1-5	女	7	看书	图书馆	与陌生人一起	00：37（视频时间）	采取保护行为	抱头躲桌子下00：37	疏散00：43		出视频00：44
20080830163攀枝花地震-攀枝花市-1-6	女	7	看书	图书馆	与陌生人一起	00：37（视频时间）	张望	抱头躲桌子下00：42	疏散00：48		出视频00：51
20080830163攀枝花地震-攀枝花市-1-2	女	8	看书	图书馆	与陌生人一起	00：03（视频时间）	张望	疏散00：07			出视频00：11
20080830163攀枝花地震-攀枝花市-1-8	女	8	看书	图书馆	与陌生人一起	00：37（视频时间）	继续原来的活动	疏散00：39			出视频00：41
20080830163攀枝花地震-攀枝花市-1-10	女	8	看书	图书馆	与陌生人一起	00：37（视频时间）	继续原来的活动	疏散00：39	张望00：40疏散00：41		出视频00：45
20080830163攀枝花地震-攀枝花市-1-1	男	9	看书	图书馆	与家人一起	00：03（视频时间）	张望	疏散00：09	等家人00：11		出视频00：14
20080830163攀枝花地震-攀枝花市-2-5	男	10	走路	大厅	独自一人	00：04（视频时间）	张望	疏散00：08			出视频00：10
20080830163攀枝花地震-攀枝花市-1-11	女	10	看书	图书馆	与陌生人一起	00：37（视频时间）	采取保护行为	抱头躲桌子下00：40	疏散00：53		出视频00：56
20080830163攀枝花地震-攀枝花市-3-1	男	12	上网	电子阅览室	与陌生人一起	00：02（视频时间）	张望+与他人交流	疏散00：04			出视频00：08
20080830163攀枝花地震-攀枝花市-3-3	男	13	上网	电子阅览室	与陌生人一起	00：19（视频时间）	采取保护行为	疏散00：21			出视频00：29
20080830163攀枝花地震-攀枝花市-3-2	女	13	上网	电子阅览室	与陌生人一起	00：19（视频时间）	采取保护行为	疏散00：21			出视频00：29