Visualization and Analysis of Safe Routes to School based on Risk Index using Student Survey Data for Safe Mobility

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Abstract— **Risk analysis is important in heterogeneous industrial domains to enable sustainable development. Data is the basis for emphasizing the potential risk elements for improving efficiency, quality, and safety. For supplying safe routes to schools based on risk analysis, the risk assessment of routes is one of the widely used and very effective methodologies to filter the most dangerous roads, intersections, or specific points on roads. This paper presents a visualization and analysis of the risk assessment approach based on the risk index model using geographical information, including routes, danger points, and student survey data. The proposed risk index model is used for deriving a risk index based on geographical information, including danger points and a route's path. The model includes an equation to calculate the distance of danger points to the path using the coordinates of each location. The survey data is mainly comprised of route and survey information that is analyzed and preprocessed for the input data of the risk index model. The survey mainly consists of basic information on the route, survey participants, school route information, and school route coordinates. The data is classified into the school route data set and the school route danger points data set, and these values are applied to the analysis and the risk index model. Also, the risk index model is designed and developed through the analysis of routes.**

Keywords— **Risk analysis; risk index; safe routes to school; data pre-processing; data analysis.**

I. INTRODUCTION

The attention to road safety-related problems has grown fast in recent decades. Road accident is a significant threat that accounts for the considerable loss of lives and cost to society [1]–[3]. Statistics show that a child every three minutes and 3000 lives every day [4] face different road problems worldwide. To enhance road safety, the United Nations has declared the decade of 2011- 2020 as the road safety decade, thus increasing the importance of Road Safety Analysis (RSA) [5]. RSA is a preventative procedure for analyzing prospective security issues for pedestrians and drivers and finding optimal solutions to eliminate or decrease road dangers or crashes [6]. Various factors can be consequences of road accidents, such as vehicles, population, road network length, and the infrastructure of the road sections. These factors are categorized as public-related, traffic-related, and collective and dynamic-related risk factors [7]–[9]. Many theoretical and practical attempts have recently reduced road dangers and accident rates in recent decades. However, these solutions seem to be in their initial process because of the lack of knowledge regarding road infrastructure, human behavior,

and vehicle mechanisms [10]–[12]. For these reasons, societies, institutions, international organizations, researchers, and individuals are paying attention to improving the transportation structure and control functionalities to decrease crash levels, as well as the road infrastructure has been analyzed deeply to detect the black spots on roads [13], [14]. Over the last decades, many resources and attention have been invested in the improvement of road user's protection. A safe road traffic system is defined as one that accommodates drivers' and pedestrians' safety [15], [16]. Several new types of technologies have been deployed to enhance driver safety, such as intelligent airbags [17], automatic vehicle brakes [18], self-control systems, and to name a few. However, these efforts seem insufficient to reduce the risks and crashes on the roads because road infrastructure also plays an essential role [19]. The road safety level can be improved by analyzing, planning, reconstructing, and monitoring [20], [21]. Various tools and applications have been suggested and promoted to increase road safety.

In this paper, we propose a visualization and analysis of the risk index model through the routes and risk points on these routes based on survey data on children's going to and coming

from schools. The data used for this study was survey-based information collected from 1707 participants from 11 elementary schools. The survey data is analyzed and processed to find the paths for children to go and return to school. The survey mainly consists of basic information on the route, survey participants, school route information, and school route coordinates. The data is classified into the school route data set and the school route danger points data set, and these values are applied to the analysis and the risk index model. The rest of the paper is structured as follows. Section 2 presents the proposed school route risk index model and the survey dataset with its parameters. Section 3 presents the proposed model's implementation details and experimental results. The conclusion and future directions are discussed in Section 4.

II. Materials and Method

In this section, the proposed risk assessment approach architecture is presented. Fig. 1 presents the risk index model calculation configuration diagram based on the input and output parameters. Input parameters for the risk index model contain routes to the schools and danger points in these routes, and the coordinates of these input parameters are described in latitude and longitude units. The route coordinates present the children's back-and-forth routes to school and home. These routes include multiple risk points collected from school children through the survey. Both routes and risk points on routes are used as inputs to the risk index model. The risk index model derives the risk index value through the risk point's latitude and longitude coordinate values and each path point.
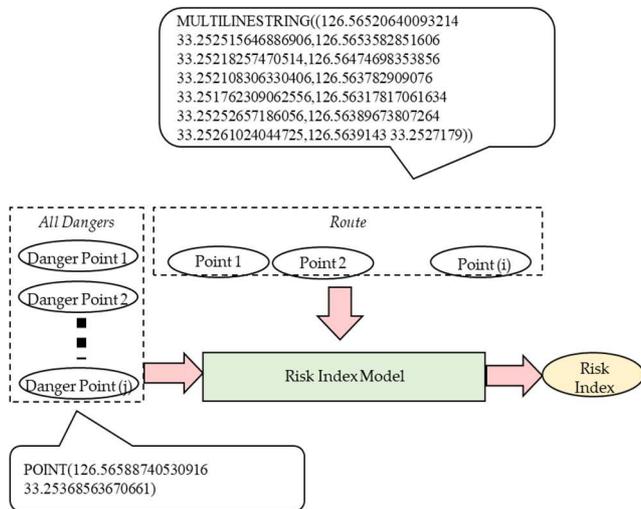

Fig.1 Parameters-based configuration diagram for the risk index model

The original dataset of the school children's survey is presented in Figure 2. In the dataset, each row contains ID, survey type, family member, living with grandparents, grade, gender, and school information. The number of rows in the dataset is 1707, the ID is described in four digits, and the values of the questionnaire type are all 10, that is, students. Students who participated in the survey were recruited from 11 elementary schools.

No.	id	Surveyee _Type	Family_C ount	Is_Grand Parents	Grade	Gender	School
1	4551	10	3	0	5	M	School10
2	4552	10	4	0	3	F	School10
3	4553	10	6	1	3	M	School10
⋮							
1705	8547	10	5	1	3	F	School06
1706	8548	10	5	1	3	F	School06
1707	8549	10	6	0	3	F	School06

Fig. 2 Original dataset of school children survey

III. Results and Discussion

Fig. 3 compares the number of students who attended various school surveys. Students who attended the survey live in the same city, all elementary school students. The students who attended the survey were selected from 11 elementary schools, including Donghong Elementary School (School01), Beophwan Elementary School (School02), Seogwi Elementary School (School03), Seogwibuk Elementary School (School04), Seogwiseo Elementary School (School05), Seogwijung Elementary School(School06), Seogwipo Elementary School(School07), Seoho Elementary School (School08), Jungmun Elementary School(School09), Topyeong Elementary School (School10), and Hyodon Elementary School (School11) in Seogwipo City.
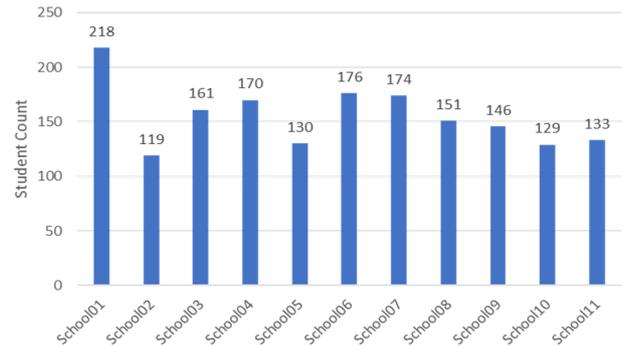

Fig. 3 The number of students in the survey from various schools

Recruitment The survey includes basic information about these students, as well as information about school attendance and dismissal routes. The average number of attendees is 155, and Donghong Elementary School provides the highest number of attendees with 218 attendance, while Beophwan and Topyeong Elementary Schools were ranked last on the list and accounted for 119 and 129 students, respectively.
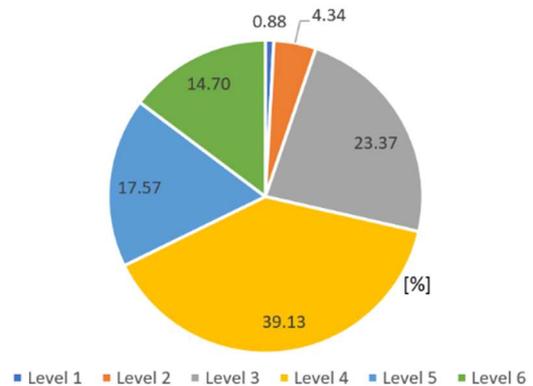

Fig. 4 Risk-based percentage of each home-to-school routes

Fig. 4 shows the percentage of danger levels based on survey results. The largest proportion of danger levels in the dataset was comprised of 39.13% (danger level 4) of overall danger levels, whereas the smallest shares of danger levels were 0.88% and 4.34% for danger level 1 and danger level 2, respectively. The second highest contribution for danger level was accounted for danger level 3 with 23.37%, according to the survey. There was little difference between the Figure of danger level 5 and danger level 6, as the former contributes the third-highest percentage with 17.57%, whereas the share of the latter was marginally lower (14.7%).

Fig 5 presents the pseudocode for implementing the read dataset value function. First, get the dataset by reading the CSV file and assign a value to the variable data CSV.

```
Method: preProcessData
Input: Student Survey Data
Output: routeList
1 :    dataCSV := Student Survey Data
2 :    FOR all item in dataCSV DO
3 :            RouteVo routeVo = new RouteVo();
4 :            route.id := id
5 :            route.genderCode := genderCode
6 :            route.transportCode := transportCode
7 :            route.dangerLevel := dangerLevel
8              route.dangerIndex :=dangerIndex
9              path := path
10             FOR all coord in path DO
11                     Pre-process latitude and longitude data from coord
12                     Add coord to pathList
13             END FOR
14             IF danger point is not empty THEN
15                     Pre-process latitude and longitude data from danger point
16                     Add danger point to dangerList
17             END IF
18             route.path := path
19             route.dangerList := dangerList
20             Add route to routeList
21     END FOR
```

Fig. 5 Reading dataset values

The variable data CSV is of type List <String []>. The value of each cell included in the following rows is assigned to the variable routeVo of type RouteVo. The value of the route is of type MutilineString, which is parsed and included in the variable coordVo of type CoorVo and put into routeVo. In this way, the location coordinates of the danger point are also parsed and put into the variable DangerVo of type DangerVo and put back into routeVo. Finally, add the final routeVo from the static variable route list.
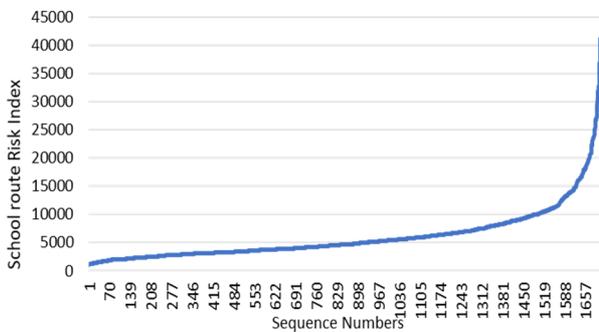

Fig. 6 Home to school routes risk index results

Fig 6 presents the result of the risk index for the school route. The risk index value collected through the risk index

model is derived from the route elapsed when each student goes to school and the risk points collected from all students. The risk index derived based on the school route dataset is in the range of a minimum 1032.854 and a maximum of 41183.41. 87.46% of the risk index of the school route has a value of less than 10000.
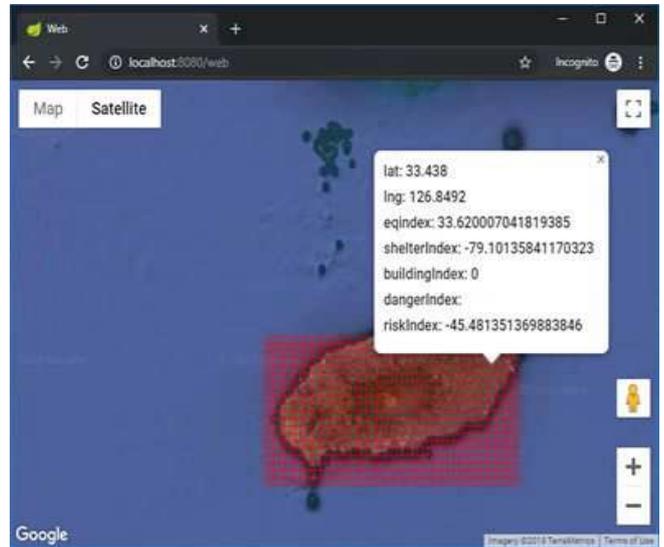

Fig. 7 Visualization results based on Map

Fig 7 presents the results of visualization based on the Map. The map-based application is implemented using Google Map APIs based on JavaScript. We implement the client application using web client frameworks that are enabled to implement using the JavaScript sources. The map presents the information of points by geographical coordinates.

IV. CONCLUSION

To provide a predictable risk assessment to improve the quality of school life, in this paper, we proposed a school route analysis approach based on a risk index model to provide a risk index. We use survey data collected from 1707 students of 11elementary schools to derive the risk index using the risk index model. The risk index model is implemented based on the proposed equation that results in the risk index by calculating the distance of coordinates. The risk index derived from the school route dataset ranges between 1032.854 and 41183.41. In the risk index of the school route, 87.46% is less than 10000. The risk index derived from the discourse path dataset is at least 669.6247 and at most 66040.45. 93.49% in the risk index of the dismissal route is less than 10000.

In future work, we will apply the proposed risk index model to recommendation applications based on learning approaches for providing smart services to students. The application can provide the user with one or more optimal routes through analysis and prediction based on data using the proposed approach and prediction algorithm.

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