Original Article

Web-Application Development In Transportation Planning Analysis For Urban Planning

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Abstract

The objectives of this research are to develop a transport application for urban development and to compare this developing program with the licensed program for traffic analysis. The data analysis in this research was imported from two databases, namely the GIS 1:4,000 database and the Engineering Survey Database of the Department of Public Works and Town & Country Planning. The scope of area in this study was the Hua Hin Comprehensive Plan, in Prachuap Khiri Khan Province. The application can estimate the existing and forecast trips on the transport network with a 4-step model method. Also, users can use it free of charge and on various devices via a web browser program. In the existing analysis of current trips, the correlation coefficient with traffic count data is 0.67, while the correlation coefficient for the licensed program for traffic analysis is 0.59. This result shows that the development of this program is successful and can be used to support transportation planners in preparing urban plans well.

Index Terms— Handle Assembly, Two-wheeler vehicle, Vibration.

INTRODUCTION

Presently, the Town & Country Engineer in Bureau (TCEB), Department of Public Works and Town & Country Planning, is mainly responsible for doing the transport urban planning in Thailand. The TCEB has set up GIS 1:4,000 databases all over the country to give urban planners the information they need. The transport planners use this database and field survey data (Mid-block traffic count, turning movement count, Roadside Interview Survey, and Physical Inventory Survey) to analyze the network performance to draw the transport city plan. The trip rate of each building type is also researched by TCEB's study for estimating the generated trips of 37 building types [1]. However, it has seldom been considered for transport planning.

There are many programs for analyzing transportation. One of the popular programs is CUBE, which is a commercial transport modeling software. But sometimes CUBE is hard to use and doesn't match the way the Department of Public Works and Town and Country Planning works or the physical data (1:4,000). Therefore, the researchers came up with the idea of developing an application for transport analysis for comprehensive urban planning that matches the data and operations of the Department of Public Works and Town & Country Planning.

This research is to develop the transport web application to help the transport planner analyze the travel patterns, both existing and forecasted, for doing urban plans based on GIS 1:4,000 database, field survey data, TCEB's trip rate and workflow. This application, which can be used anywhere with a web browser and is a free program, aids planners in cutting down on the time and expense associated with analysis. As a case study, the urban region of Hua Hin is used to test how accurate the application's results are using traffic count data and CUBE results for a real-world scenario and a future scenario.

Objectives

1) To develop a transport application for urban development
2) To compare this developing program with the licensed program for traffic analysis

Theoretical contribution

The transport model consists of four contiguous sub-models as follows.

The Trip Generation Model

The trip generation model is an analysis of trip production and trip attraction in relation to socio-economic data within

the sub-study area, for example, number of households, number of populations, number of employments, etc. There are several methods for forecasting the number of trips, such as regression analysis, cross-classification analysis [2], and the trip rate method, etc. But the regression analysis method is popular because it shows the relationship between factors that cause and attract travel.

$$Y = a_1X_1 + a_2X_2 + \cdots + a_nX_n + C$$

Y = Trip Production and Trip Attraction

$X_1, \ldots, X_n$ = socio-economic data within the sub-study

area, for example, number of households, number of populations, number of employments, etc.

$a_1, \ldots, a_n$ = variable coefficient

Trip Distribution Model

These generated trips from each zone are then distributed to all other zones based on the choice of destination [3]. The Doubly Constrained Gravity Model is a widely used method in traffic and transportation planning, which is a technique for distributing travel using friction factor to travel between pairs of study areas as shown in the equation.

$$T_{ij} = \alpha_i \beta_j P_i A_j F(c_{ij})$$
$$F(c_{ij}) = c_{ij}^{a} * \exp(b * c_{ij})$$

T_{ij} = amount of travel from sub-study area i to

sub-study area j.

P_i = Total travel incidence of sub-study area i

A_j = Total travel attraction volume of sub-study area j

$F(c_{ij})$ = Travel expense function between sub-study

areas i and j

α_i , β_j = The specific Balancing Factor of row i and

column j

C_{ij} =The cost of traveling between sub-areas i and j

a, b =Model correction fee

The Modal Split Model

The modal split model is an analysis to find the proportion of people choosing different travel styles. which consists of traveling by personal car and public transport by using the Logit Method to analyze the behavior of decision-making in choosing travel patterns. In short, this model shows the percentage of travelers using a particular mode of transport compared to the ratio of all trips made [4]. This is based on the utility the traveler receives from each mode of travel. The form of the equation is as follows.

$$P_n(i) = \frac{e^{U_{in}}}{\sum_{j \in C_m} e^{U_{jn}}}$$

$$U = aT + bC + c$$

$P_n(i)$ = Probability of the person choosing the n^{th}

journey of choice i.

U_{in} = The utility of choice i of the n picker

U_{jn} = The utility of choice j of the n picker

C_m = Total number of choices

j= Option j, such as walking, bicycle, personal car

or bus, etc.

T = Travel time of choice

The Trip Assignment Model

The trip assignment model is an analysis to quantify travel between sub-study areas in a network for analysis. In this study, capacity restraint and user equilibrium methods were applied. It is based on the postulate that travelers can acquire the variability of route travel times from past experiences and factor such variability into their route choice considerations in the form of mean route travel time [5]. The Equilibrium Assignment method is used to calculate the optimal traffic volume on different road sections with the following objective functions:

$$z = \sum_{a} \int_{0}^{v} c_a(v)dv + \sum_{a-b} c_{a-b} v_{a-b}$$

$c_a(v)$= the cost of travel incurred during the road

c_{a-b} = Travel expenses from road a to road b

v_{a-b} = Traffic volume from road a to road b

v_a = The amount of traffic on the road block a

Methodology

Existing travel analysis has been conducted in the Hua Hin urban area, located in Prachuap Khiri Khan Province about 200 km from Bangkok in the west. TCEB constructed the GIS 1:4,000 database and collected the engineering field survey data in 2012. This study pretends that this year is the current year for analyzing the travel in the existing analysis case. The Hua Hin network consists of 114 TAZs (Internal Zone: 101, External Zone: 13). The number of nodes is 626, and the number of links is 1,956.

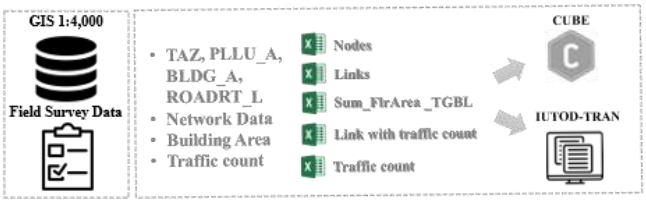

Fig. 1: Data Framework

The building areas of 37 types (shown in Table 1) are extracted from the GIS 1:4,000 database. For traffic count data, there are a total of 121 stations in all urban areas.

Table 1: Building types with travel incidence rate according to TCEB's study

Building types			
1.Single house/ twin house	11. Fuel Station	21. Factory	31.Government Hospital
2. Townhouse	12.Commercial building	22. Warehouse	32.Private Hospital
3. Row houses	13.Fresh markets	23. Piers	33.Government buildings
4.Condominium for rent	14. Department store	24. Airport	34.Zoo, amusement park, botanical garden
5.Condominium for trading	15.Retail stores	25.Railway station	35. Auditorium
6. The hotel focuses on providing rooms	16.Supermarket	26. Bus Station	36. Sports field /multipurpose gymnasium
7. Hotels that provide rooms and ancillary services	17. Bank	27. Elementary school	37. Park
8. Resort-style hotel	18. Small office building	28. Secondary school	
9.Nightclub/Cafe	19. A large office building	29. University	
10.Restaurant	20.Industrial Estate	30. Vocational Education	

Due to a lack of HIS and RIS data, the data from 29 stations is used in the Matrix estimation module to build the deterrence function. The deterrence function for Hua Hin is $F(C_{ij}) = C_{ij}^{-1.15}$. Next, the EE IE/EI trip module produces the trip end outside the study area. The trip distribution module estimates the OD table; then the trip assignment module allocates the trips into the network. The output of the trip assignment module is the traffic volume on each link in a speed sheet file (.csv) that can be brought into ArcGIS to display the travel on a map (.shp).

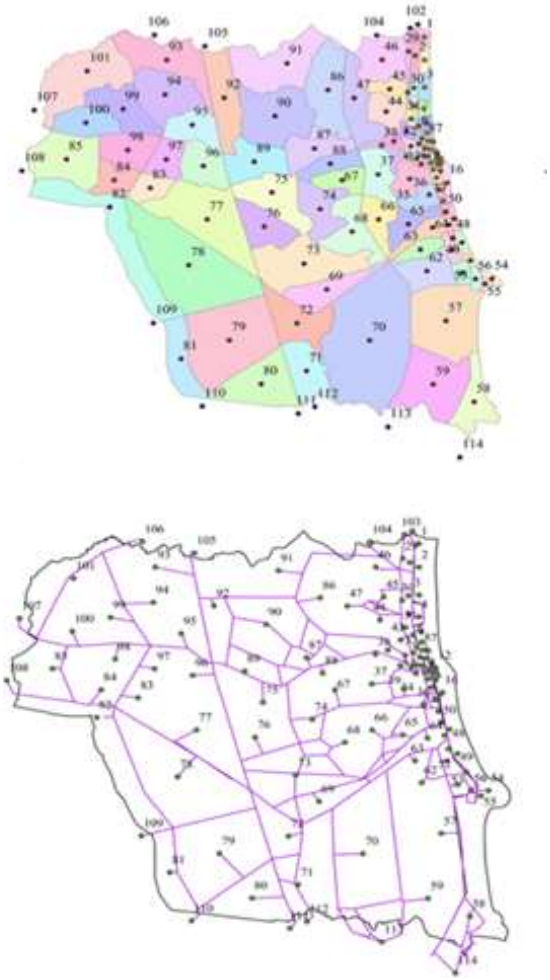

Fig. 2: TAZs and transport network in Hua Hin

The result of web application development

The web application "Innovation of Urban and Transport-Oriented Development" (IUTOD-TRAN) was developed with a four-step model. IUTOD-TRAN comprises six modules: 1) Module for trip generation; 2) Module for trip distribution; 3) Module for trip assignment; 4) Trip module EE, IE/EI; 5) The matrix estimation module; and 6) the shortest path module. The trip generation module can calculate the trip end (the number of trips originating in or destined (each mode) for a particular traffic analysis zone) from the building area of each building type (37 types) by TCEB's trip rate. The origin-destination table, which contains the number of trips that occur between each origin zone and each destination zone, can be predicted with the gravity model method. The trip assignment module then concerns the selection of routes between origins and destinations and calculates the traffic volume with an all-or-nothing algorithm. The external - external, internal - external, and external-internal trips can be estimated from traffic count data outside the study area following the National Cooperative Highway Research Program Method [6]. The Matrix estimation module can help the planner find an origin-destination trip table or deterrence function from traffic count data in the case of no household interview survey or roadside interview survey data. Lastly, the shortest path module finds the shortest route (in terms of distance or time) through all of the traffic analysis zones and shows a graphic of the transport network.

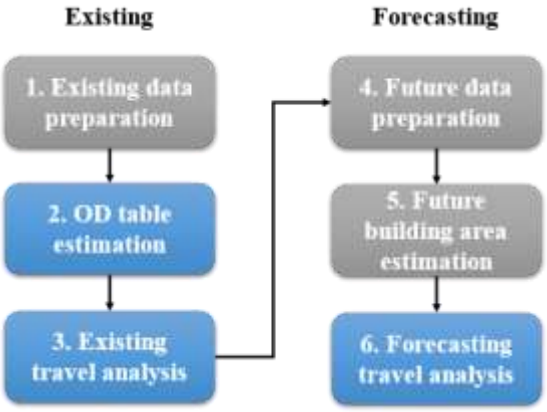

Fig.3: Analysis Process with IUTOD-TRAN

The analysis process using this application consists of six steps as follows: 1) existing data preparation, 2) estimation of the Origin- Destination (OD) table, 3) existing travel analysis, 4) forecasting data preparation, 5) future building area each type of buildings estimation, and 6) forecasting travel analysis (Fig. 3). For existing data preparation, the GIS 1:4,000 database and traffic count data must be formed into IUTOD-TRAN format and type (.csv).

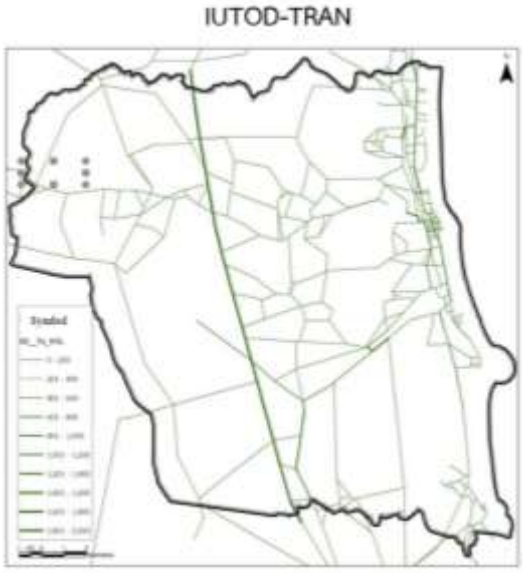

Fig. 4: Traffic volume by IUTOD-TRAN

The input data includes the network, the building area, and traffic count. The planner prepares the network with ArcGIS or other GIS software by defining the traffic analysis zone (TAZ), centroids, nodes, and links; then, exporting them into the right format. Also, the building area data comes to inquire from the GIS 1:4,000 database. Secondly, the user runs this procedure to get the origin-destination trip table in the case of no OD table. Trip generation module, EE IE/EI trip module, shortest path module, and matrix estimation module are involved. Then, the existing travel analysis step will handle the EE IE/EI trip module, trip distribution module, and trip assignment module to get the traffic volume on the network. The forecasting analysis has 3 steps. Firstly, the user must prepare the forecasting network and traffic volume the same as the existing analysis process. For future building areas, the subjective or Delphi method has been applied by considering the city policy, GIS database, and proposed city plan. Finally, the trip generation module, EE IE/EI trip module, shortest path module, trip distribution module, and trip assignment module will be used to determine future travel on the proposed network. This procedure will be followed to find the existing and forecasted trips on the Hua Hin network, and the output from the application will be compared with CUBE.

The result of comparative study

Existing Travel Analysis

The results have been tested with traffic count data by MAE, MSE, and GEH. MAE is 287.80. MSE is 156,638 and GEH < 15 is 60%. The correlation coefficient with traffic count data is also 0.67. Hence, the travel from IUTOD-TRAN and traffic count data is slightly significant (Fig 4 - 6).

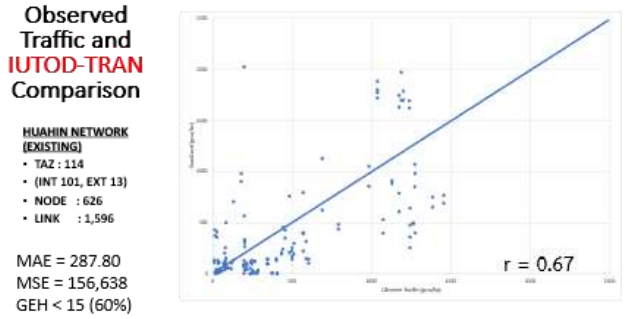

Fig. 5: The result of comparison between IUTOD-TRAN and Mid-block traffic count data

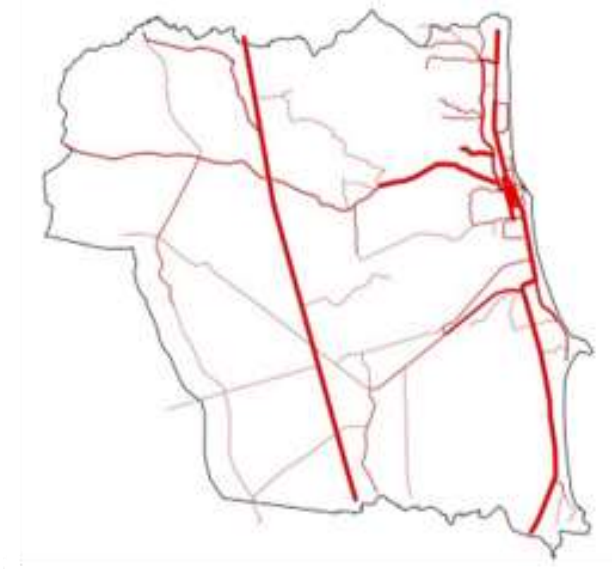

Fig. 6: Traffic volume by Mid-block Traffic count data

Using the same data, additionally, the traffic volume from CUBE has been evaluated such that MAE is 425.70, MSE is 420,248 and GEH < 15 is 49 %. Then, the correlation coefficient is only 0.59 (Fig 6-8). Hence, IUTOD-TRAN's results are more significant than CUBE's.

Fig.7: Traffic volume by CUBE

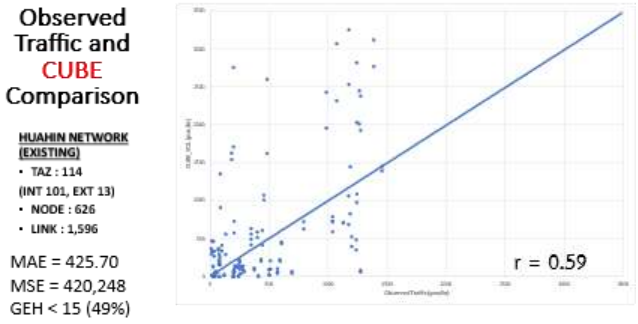

Fig. 8: The result of comparison between CUBE and MID-block traffic count data

Furthermore, the correlation coefficient between IUTOD-TRAN and CUBE is 0.57 (Fig. 9). It can be concluded that the results of both applications are in the same direction.

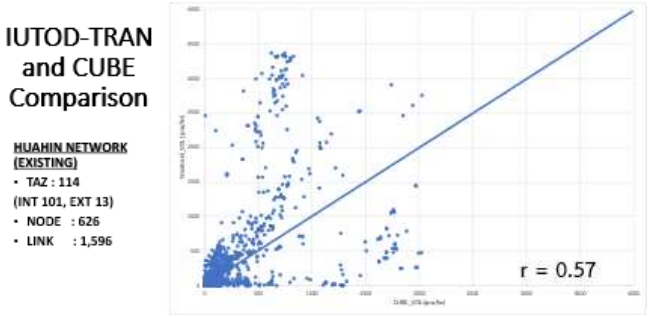

Fig. 9: Traffic volume comparison between IUTOD-TRAN and CUBE

Forecasting Travel Analysis

IUTOD-TRAN can predict the future travel on a network based on historical data. The planner must prepare data like the existing analysis but in the proposed year (2032).

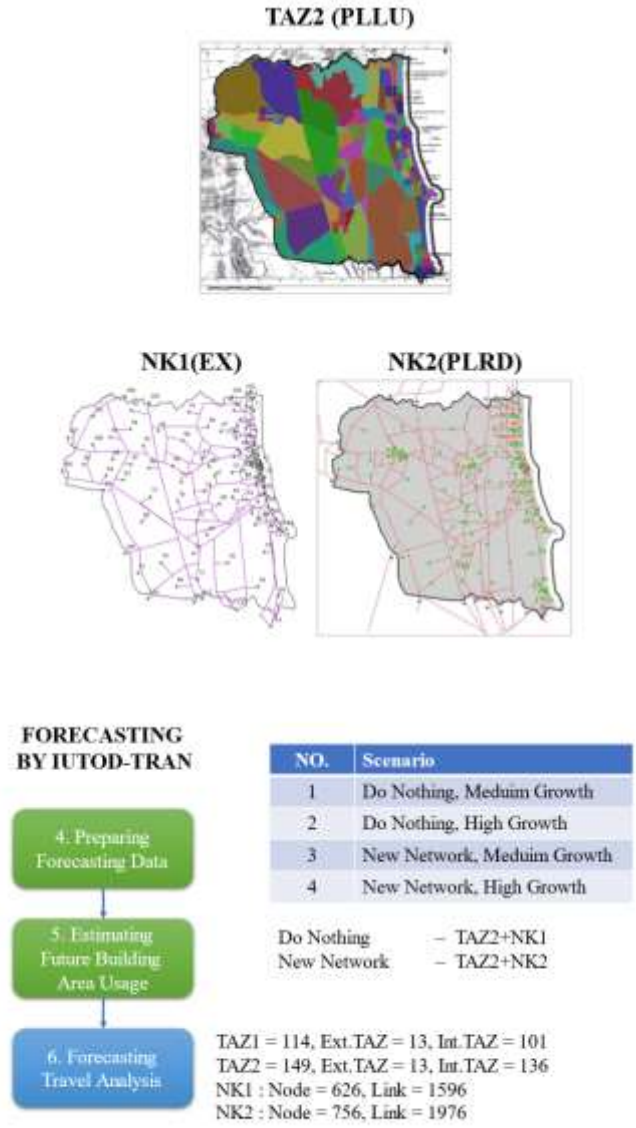

Fig. 10: Forecasting process with IUTOD-TRAN and scenarios

The building area is the important key to analyzing with IUTOD-TRAN. The building area data used in this research was received by a professional city planner using the subjective method to calculate the data, considering the city policy, the GIS 1:4,000 database, and the proposed city plan. Like the building area, the traffic volume data has been estimated for external trips by the growth rate method. The networks have been prepared depending on alternative scenarios. For this research, there are 4 scenarios to investigate the network's performance as follows: 1) a do-nothing network with medium-growth; 2) a do-nothing network with high-growth; 3) a new network with medium growth; 4) a new network with high-growth (Fig.10).

The do-nothing network is the same as the existing network, and the new network is the road network in the proposed city plan. The building area in future years can be calculated with the growth rate method. The medium and high growth rates per year are 5% and 10%. Then, the trip generation module, EE IE/EI trip module, shortest path module, trip distribution module, and trip assignment module are all executed in order. The output is the traffic volume on a network.

IUTOD-TRAN and CUBE produce traffic volume for comparison. According to the comparison, IUTOD-TRAN and CUBE have correlation coefficients of 0.63, 0.62, 0.70, and 0.71 for each scenario, respectively (Fig. 11 -14). As a result, IUTOD-TRAN and CUBE both provide output in the same direction.

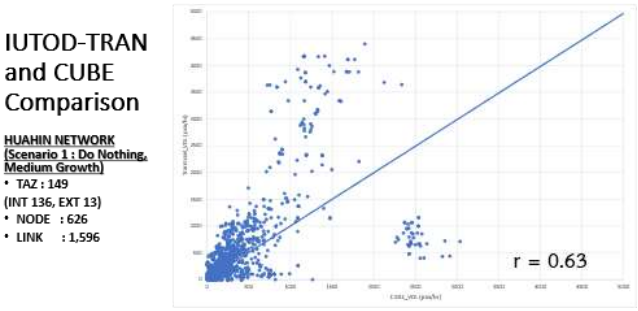

Fig 11: IUTOD-TRAN and CUBE comparison in a do-nothing network with medium-growth

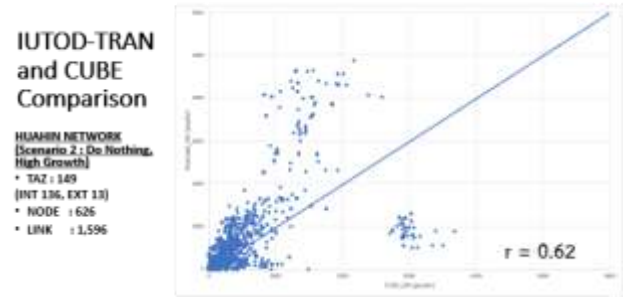

Fig 12: IUTOD-TRAN and CUBE comparison in a do-nothing network with high-growth

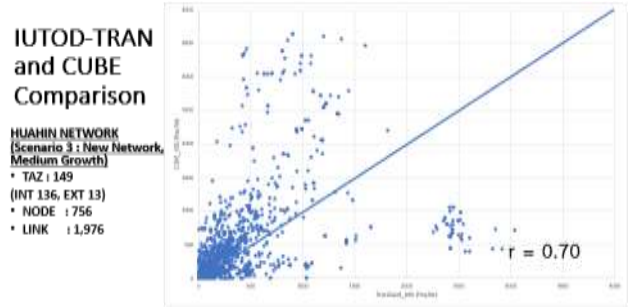

Fig 13: IUTOD-TRAN and CUBE comparison in a new network with medium-growth

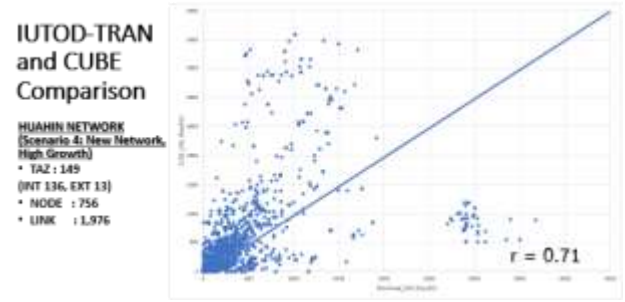

Fig 14: IUTOD-TRAN and CUBE comparison in a new network with high-growth

Conclusion

The web application "Innovation of Urban and Transport-Oriented Development" (IUTOD-TRAN) has been developed with a four-step model to help the transport planner estimate the number of trips on the transportation analysis network. IUTOD-TRAN operates on the internet network via a web browser, which works on various devices, for instance, PCs, tablets, and mobile phones. Users can use it comfortably, economically, quickly, and accurately. Based on a GIS 1:4,000 database, field survey data, TCEB's trip rate, and workflow of TCEB to estimate network travel in both the present and the future, it can help transportation planners conduct accurate, quick, cost-effective, and comfortable analyses to create transport urban plans. When compared to CUBE, the IUTOD-TRAN results are noteworthy. IUTOD-TRAN could therefore be effective for transport planners.

Suggestion

Suggestions to improve the IUTOD-TRAN application for transport analysis for integrated urban planning The details are as follows:

1) In the itinerary forecast module, an exponential function should be added for finding the deterrence function and other parameter values.
2) In the trip distribution, we should add a user equilibrium method to distribute trips.
3) Transport network import data, including point data and line data, should be able to be imported as a shape file.
4) Network traffic results should be able to be mapped in the IUTOD-TRAN application without having to display it in ArcGIS.

Use the IUTOD-TRAN application to analyze city travel models based on the size of each type of city. This will help you figure out how reliable the IUTOD-TRAN application is at each city level.

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