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# The MATLAB Toolbox for GPS Data to Calculate Motorcycle Emission in Hanoi - Vietnam

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**Abstract.** The GPS – Toolbox is a MATLAB - toolbox for calculating motorcycle emission in Hanoi. Major aim of this project is to provide a basic tool that allows novices to control basic hardware used for calculating motorcycle emission in Hanoi without limiting the power and flexibility of the underlying programming language. This toolbox was built based on two projects: Evaluation of motorcycle's emission factors in Hanoi 2010 and GPS – trip diary survey in 2010. In this toolbox, the relationship between power and emission will be applied to calculate the motorcycle emission. In addition, this toolkit can automatically identify trips and calculate emission from each trip. On the other hand, it could be developed to apply for other areas in developing countries.

The toolbox for GPS is introduced providing several scripts for dividing trips and calculating emission of motorcycles, as well as, view GPS data on maps and properties of trips second by second. It also can support to view detail trips in 3D and count total time of motorcycle spent for traffic control and traffic jam. Beside, the results which applied toolbox for Hanoi show that, there are slight differences between motorcycle emission in rural areas and urban areas.

**Keywords:** Motorcycle, GPS survey, emission, Hanoi

## 1. Introduction

According to Vietnam Register Organization, the number of motorcycles in Hanoi by the end of 2009 was 3.6 million units with an average 16% annual increase [1]. Even though the Hanoi Government has made various efforts to reduce the number of motorcycles by improving the current bus system and introducing the light rail transit system, building public transport infrastructure needs a huge amount of capital as well as much longer time. Thus, it can be foreseen that motorcycles still have to play an important role in transportation system at least within next 15 years (Ministry of Transport). It is true that ownership and usage of motorcycles have surely improved people's quality of life. Nevertheless, over-use of motorcycles also leads to various traffic problems, such as traffic congestion, traffic accidents, and air pollution. To tackle such problems, there has been no policy or regulations to control emission from motorcycles in Vietnam, to date. Therefore, it is first necessary to establish such institutional systems as soon as possible, and at the same time, it is also indispensable to build operational and reliable monitoring systems that can precisely measure emission from motorcycles. Precisely calculating the motorcycle emission will support building control policies in the future, i.e. setting up a set of regulation on motorcycle emission control.

As stated by Vietnam Ministry of Transport, all vehicles including motorcycles will be equipped with monitoring devices which can record speed, time and location such as GPS or motor tracker in 2012 for the purpose of controlling traffic. Therefore, if data could be used to calculate motorcycle emission, the government would be able to control emission from motorcycle by each individual. On the other hand,

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individuals who own motorcycle equipped GPS device, would utilize data recorded to know emission, distance and time of their trips and optimize their route choice.

Fig. 1: Setup GPS for motorcycle

To exploit effectively of GSP capability, this study attempts to make a GPS toolbox that can easily calculate motorcycle emission based on an improved method and also can extract all information about trips by using MATLAB (Graphical user interface). This method can reflect traffic condition by using data recorded second by second. After that, new software will be created base on MALAB Compiler with the aim of assisting all residents in easily using and getting information about their trips by themselves.

## 2. Review of the Previous Study

To date, several studies on motorcycle emission inventory in Hanoi have been conducted. For example, in 2005, Swiss-Vietnamese Clean Air Program (SVCAP) suggested a specific project for the generation of emission factor using SIM-air (Simple Interactive Model for Better Air Quality) [2]. However, the emission levels were derived based on the information collected from other Asian countries and the US since there was no related information available in Hanoi. In 2008, Kim Oanh and Thuy conducted a study focusing on the derivation of motorcycle emission inventories for Hanoi [1]. Nevertheless, the emission factors and speed adjustment factors used in the International Vehicle Emission (IVE) model were based on the “Los Angeles Route Four” (LA4) driving cycle. In 2010, Tung et al. developed the emission factor and emission inventories using “Centre for Environmental Monitoring Motorcycle Driving Cycle” (CEMDC) which resulted from 10 routes of motorcycles running in the urban areas of Hanoi [3]. Limitation of this study is that it does not reflect the influence of traffic congestion and cover rural areas and so on in Hanoi.

Currently, GPS software is very popular in the world. There is a lot of software which can identify and view trips in Google map. For example TRAVTIME, it can analyze GPS data collected from probe vehicles carrying a GPS logging device. However, in the situation of Hanoi which has various problems in traffic, behavior of road users is quite different from other cities. Therefore, it is difficult to identify trips accurately. On the other hand, until now, there has been no software which can deal with automatically identifying trips, cutting trips and calculating emission for motorcycles.

## 3. Surveys and Methods

The major aim of the project was to provide a basic tool that allows novices to control basic hardware used for calculation motorcycle emission in Hanoi without limiting the power and flexibility of the underlying programming language. Therefore, we used MATLAB GUI (graphical User Interface) to make a program.

With the aim of using GPS data to calculate emission from motorcycle, the second project was conducted in Hanoi in 2011 by recruiting 65 people who only used motorcycles. In the project, these 65 persons were asked to bring GPS devices all the times outside of their homes over a week. Based on the collected all data, we make a toolbox for GPS data which can identify motorcycle trips, cut trips and calculate emissions.

Data collected in a household trip diary survey in Hanoi will be used. In that survey, information related to socio-economic of household and each respondent (> 15 year olds), vehicle information were collected. Each respondent was asked to fill in a trip diary which records all trips they make during one week in detail and to bring a GPS device in all their activities. All respondents who use motorcycles as main mode will be filtered out for examining motorcycle emission.

## 3.1. Methods

Finding from the first project show that, there are relationship between motorcycle power and emission [4]. Base on results of this project (show in Fig. 2), this toolbox will be created.

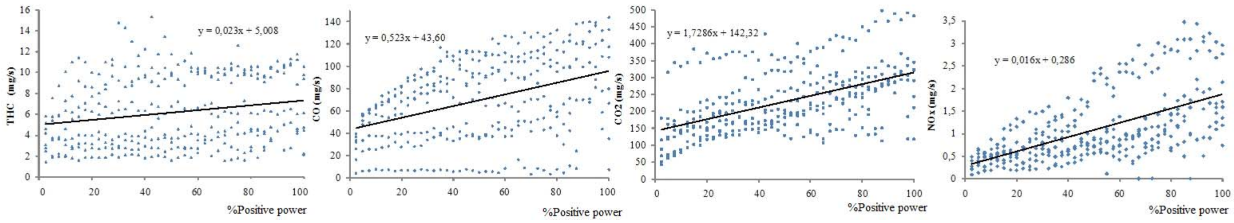



Fig. 2: Relationship between "percentage of positive power" and emission

With negative power:

Pmax- & THC: Y = 0.002x +3.386

Pmax- & CO: Y = -0.117x +40.26

Pmax- & $CO_2$: Y = 0.182x + 246.9

Pmax- & $NO_x$: Y = -0.002x +0.322

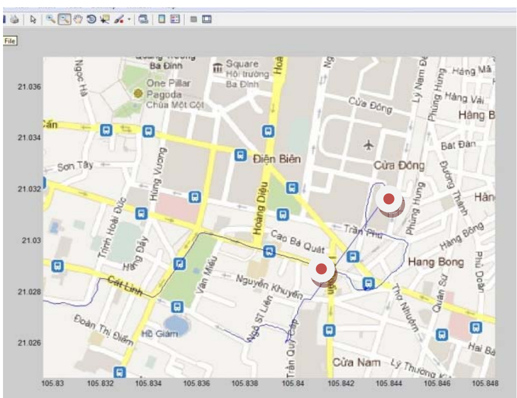
## 3.2. Core Functions of the MATLAB Toolbox

Four core functions are developed in the MATLAB toolbox: data cleaning, dividing trips, emission calculation and displaying results

### 3.2.1. Data cleaning

*For the error when the GPS device lost signal*: If GPS lost signal in less than one minute, we assume this point like previous point. On the other hand, if GPS lost signal more than one we separated into 2 data.

*For the error when the GPS device lows signal*: sometime GPS have a low signal and the number recorded is not correct (base on maximum of motorcycle acceleration). In this case we assume this point is the same with previous point.



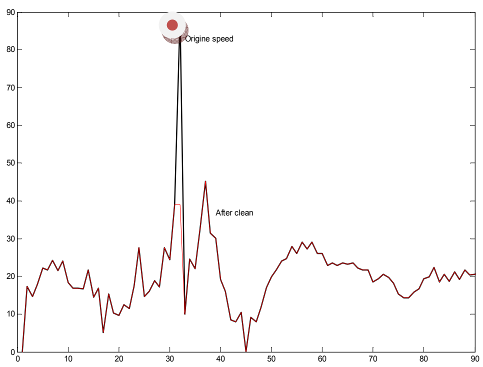




Fig.3: GPS lost signal Fig.4: Random error

### 3.2.2. Dividing trips: this process shows in figure 5 by using speed base [5] to identify start point and end point.

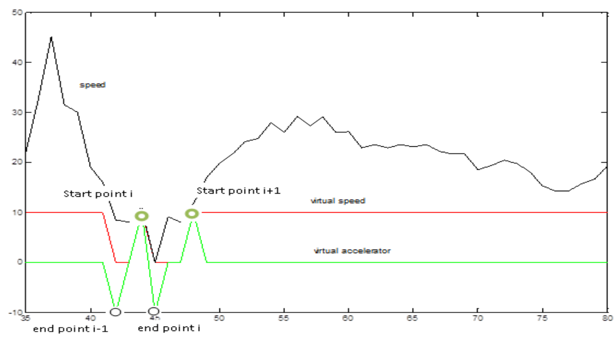



Fig.5: detected start point and end point

*Detect all start and end points*: Virtual speed is assumed, if speed > 10 km/h [6] then virtual speed equals 10, otherwise, it equals 0). Differential of virtual speed (virtual acceleration) is used to find out all points when the virtual speed changes from 0 to 10 (start point) and from 10 to 0 (end point).

*Sort start and end points*: If virtual speed equal to 0 less than 300 second, congestion and traffic control would be considered. Inversely, vehicle finished trip.

#### 3.2.3. Emission calculation: Fig. 6 shows the process of calculating emission

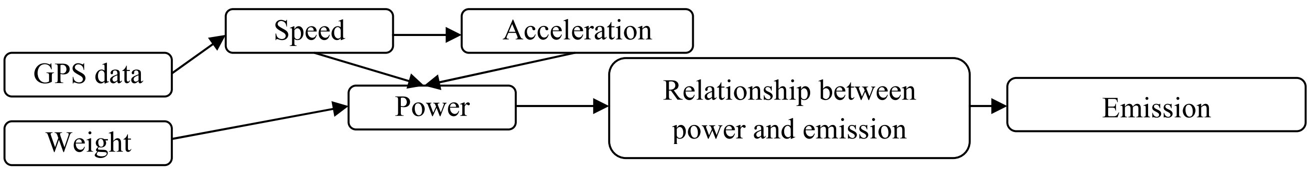



Fig. 6: Process of calculation emission

The power used for vehicle operation can be calculated based on the following equation [7]:

$$P\ (kW) = m \times [V \times [\ 1.1 * A + 9.81 \times (atan\ (\ sin\ (G))) + 0.132\ ] + 0.000302 \times V^3 + A_c]$$

| | | | |
|---|---|---|---|
| where: | m: weight (ton) | V: velocity | In case of motorcycle in Hanoi: |
| | A: acceleration | G: angle of road (radian) | - $G = 0$ |
| | | $A_c$: power share for air conditioner | - $A_c = 0$ |

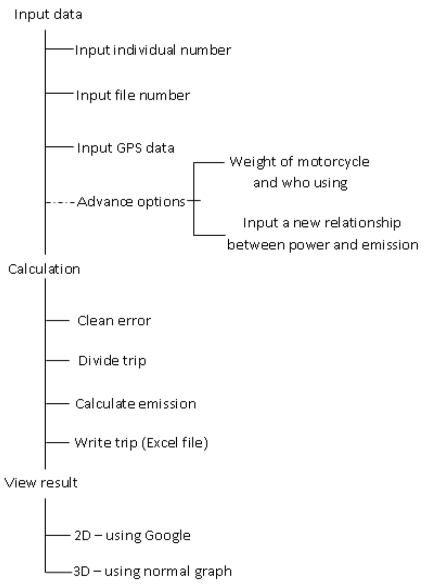
#### 3.2.4. Displaying the results

This result will be displayed for each trip, in the format of 2D or 3D. In case of 2D, the map of world [8] is used to show in figure with longitude and latitude, as well as all results of one trip in next figures including speed, power, total Hydrocarbon, CO2, CO, and NOx. In case 3D, longitude, latitude and time will be showed in one figure.

## 4. GPS Toolbox Functions

Figure 7 shows the detail step in this toolbox. In this tool, there are three main steps: input data, calculation and view result.

In addition, we extend this tool for other places by making advance input options (show in figure 8). In this option, you can change the value of all equation in method to calculate emission.



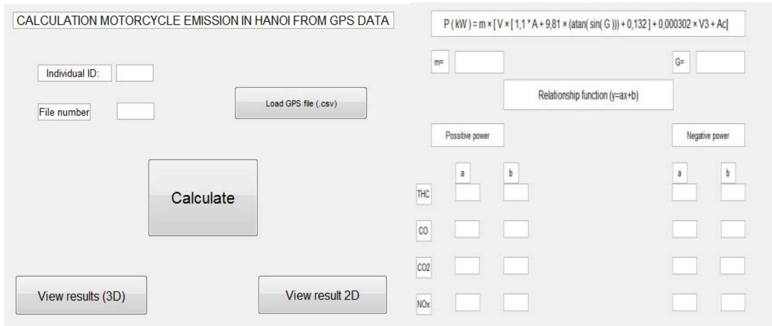




Fig.7: Process of toolbox

Fig.8: Interface of toolbox

This toolbox is very convenient for users as they only need to run this program and input parameters by themselves, then they can get detail information of each trip and compare to chose the best route.

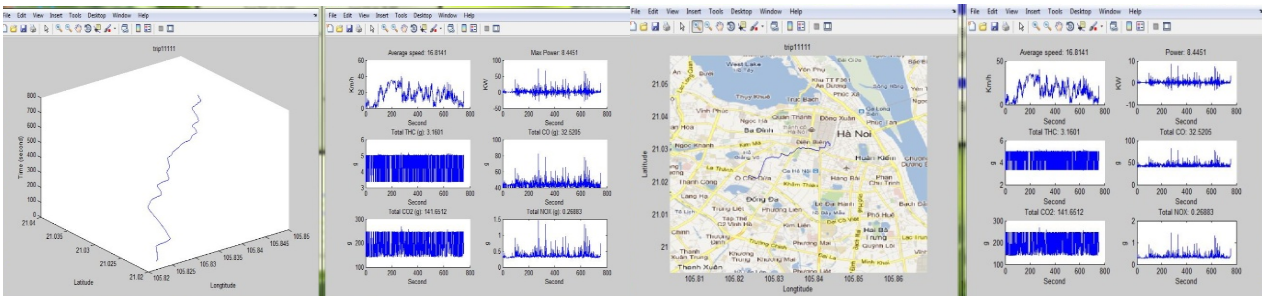


Fig. 9: View the result

Figure 9 shows the results viewed in 3D or 2D. Result file also can be accessed to find out other parameters such as total time, congestion and traffic control time, emission factor and so on.

## 5. Conclusion

The result by applying this toolbox for calculating motorcycle emission in Hanoi urban area is unremarkably different from previous studies (it is shown in table 1). It is believed that this toolbox will become useful and reliable application for residents and government in controlling motorcycle emission in Hanoi.

Table 1: Emission factor

| **Emission factor (g/km)** | **This study** | **HMDC Driving Cycle 2009** [9] | **Schippers et al. (2008)** [10] | **Tung HD et al. (2010)** [3] |
|---|---|---|---|---|
| THC | 0,923 ± 0,178 | 1,017 | 1.7 | 1.02 |
| CO | 9,448 ± 1,864 | 12,592 | 8.72 | 12.09 |
| CO2 | 38,399 ± 7,865 | 32,478 | 39.06 | 29.68 |
| NOx | 0,097 ± 0,021 | 0,180 | 0.34 | 0.11 |

Table 2: Comparison with Taiwan average emission factors for motorcycles

| **Emission factor (g/km)** | **This study** | **Taiwan** [11] | **Kao** [12] |
|---|---|---|---|
| THC | 0,923 ± 0,178 | 1.62-2.53 | 0.29-3.63 |

| | | | |
|---|---|---|---|
| CO | 9,448 ± 1,864 | 6.53-8.24 | 1.17-7.02 |
| CO2 | 38,399 ± 7,865 | 41.42-55.98 | 52.4-61.3 |
| NOx | 0,097 ± 0,021 | 0.11-0.13 | 0.001-0.26 |

On the other hand, when applying this tool for rural areas in Hanoi, there are slight differences which are shown in table 3.

Table 3: Emission factor in Hanoi

| **Emission factor (g/km)** | **This study (Urban areas)** | **This study (Rural areas)** |
|---|---|---|
| THC | 0,923 ± 0,178 | 0,5368 ± 0,269 |
| CO | 9,448 ± 1,864 | 5,9693 ± 2,234 |
| CO2 | 38,399 ± 7,865 | 24,118 ± 8,532 |
| NOx | 0,097 ± 0,021 | 0,0605 ± 0,032 |

According to table 3, in rural areas the emission factor is lower than in urban areas. The main reason is congestion and traffic control in urban areas that reduce the speed of vehicle. On the other hand, in rural areas, emission is different depending on purpose of road user’s trips, road type, etc.

## 6. Acknowledgement

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