A Conceptual Framework on Active Traffic Information to Reduce Air Pollution

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Abstract

The existing advanced traffic information system play only a passive role as information provider for the drivers to find better route, anticipate congestion and avoid traffic problem. In this paper, a new conceptual framework is proposed for the advanced traffic information system to play a more active role as an integrated system that direct the traffic to reduce the overall congestion and reduce air pollution through traffic modeling and monitoring. Public trust on the traffic information can be utilized to guide the drivers not only to avoid congestion but also to travel on less concentrated air pollution areas. When the amount of traffic density can be widely distributed over space and time, the overall air pollution concentration can be reduced in shorter time.

Keywords: Advanced Traffic Information System, Floating Car Data, Pollution Reduction, Green Traffic Info

1. Introduction

Traffic information system is distribution of information about road conditions such as traffic congestion, detours, and traffic accidents as public broadcast program. Usually, it is done through radio, television, web sites, cellular phone, mobile device applications or automotive applications (such as GPS unit). It is common that traffic info also include traffic congestion maps, alternate travel routes and travel times for each route.

Traffic information has been developed in many countries and cities as can be search easily over the internet. In the Philippines, in particular, there is existing traffic information system built by Metro Manila Development Authority (MMDA). The MMDA app is limited only to two major arterial roads (Katipunan and EDSA) and the data comes from manual report by thousands of MMDA personnel. The data is then updated manually and showed in the web and mobile devices.

The researchers in Pedestrian and Traffic Lab of Ateneo de Manila University recently are developing an improvement of the existing traffic information system. Department of Science and Technology, and Department of Transportation and Communication of the Philippines (DOTC) provided the funding to install GPS box with SMS and wireless communication device to several hundred taxis and government vehicles. Some of our floating vehicles also equipped with pollution sensor along with the GPS. Our system is often called Floating Car Data (FCD) using the Global Positioning System (GPS). FCD provides more reliable approach analyzing the travel time and routes of vehicles on urban roads. With increasing number of private vehicles are using GPS, it is our hope that the data collection would be more reliable.

Our system tracks trajectory data from vehicles every several seconds. The data is then being converted into speed and flow and travel time for public traffic info. Providing this traffic and pollution information to public would be our next step. In the background, the system also computes generalized origin destination flow for transportation planning purposes based on algorithm described by Teknomo and Fernandez (2014).

Traffic information helps driver to anticipate and avoid traffic problems. Traffic information helps drivers to find better routes and reduce the overall travel time. Several driver navigation systems such as Google Waze use community-based traffic report to

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share their real-time traffic experience and road information on the best route.

Transportation is derived demand from people's activity. The existence of traffic information does not reduce the overall traffic volume in general. People who need to travel will still travel to their work or school regardless the information about the traffic. The overall origin destination volume will not reduce simply by providing traffic info. Similarly, air pollution does not go away simply by providing information on where are the most polluted areas.

The existing traffic info plays passive role only as information provider. Beyond the existing current traffic and pollution monitoring and traffic and air pollution information system, presenting the information to public would lead us to think whether we can reduce the traffic congestion or reduce the air pollution caused by the traffic. In this paper, we are presenting our conceptual framework on how to utilize traffic information to reduce the concentration of air pollutions. We can express our problem as follow. Given the existence of traffic information system, how to make such public traffic information as a useful means to reduce the air pollution due to heavy traffic in certain areas.

2. Related Literature

Transportation is a very important societal element because it supports socio-economic activities. Access to services, amenities and goods is inseparably linked with the development of mobility and the choices that people make. More and more societies rely heavily on private motorized transport (i.e. automobiles) for their mobility needs because of its flexibility, convenience and speed. However, Kenworthy and Laube (1996) have argued that the automobile represents a major cause of environmental impact in developed and developing countries around the world. WHO (2005) indicated that about 100,000 deaths a year could be linked to ambient air pollution in cities in the WHO European Region, shortening life expectancy by an average of a year. The transport sector in the Philippines contributed to as much as 23 million tons of CO_2 in 2011 from which 87% came from roads. The ensuing consequences of motorized transport are increased fuel consumption, greater emissions of air pollutants, and increased health risks. The increased deterioration of air quality due to vehicle emissions is apparent in cities and countries which have a high dependence on motorized transport. Figure 1 shows a list of environmental and health impacts of traffic and transport infrastructure. Some of the negative externalities from transport use are summarized as environmental effects, health effects, social and cultural impacts. These impacts are mainly caused by pollutant emissions, noise emanating from vehicles and infrastructure built to support mobility.

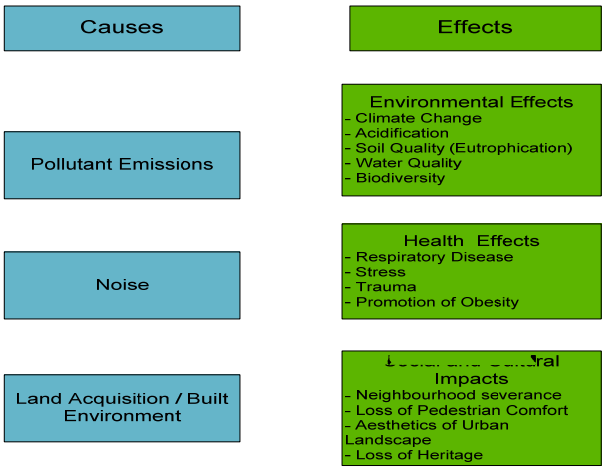

Figure 1 Cause and Effect of Pollution, Noise and Built Environment Source: adapted from Himanen, et al (2008)

The importance of addressing air pollution based on traffic has been highlighted by many studies. For instance, Brauer et al (2002) evaluated the effects of traffic-related air pollution on health, such as its influence on the development of asthma and other childhood respiratory diseases. They found strong associations between the amount of traffic-related air pollution and the development of asthmatic/allergic symptoms and respiratory infections.

Among the environmental factors that play major roles to the amount of traffic related air pollution, several studies highlighted distance, traffic density (not traffic flow) and downwind as the main factors. Janssen et al 2001 assess exposure to air pollution from traffic of children attending schools near motorways. The study found out that concentrations of air pollutants in and outside schools near motorways are significantly associated with distance, traffic density and composition, and percentage of time downwind. Gilberta (2003) measured the variation of ambient nitrogen dioxide (NO2) concentration with increasing distance from a major highway. They found out that concentrations of NO2 decreased significantly

with increasing logarithmic distance from the highway. Concentrations of NO2 were also significantly lower upwind than downwind relative to the highway.

The existence of real time traffic information does reduce traffic congestion mainly due to the shift of the departure time rather than the demand to travel. Csikós and Varga (2011) provided road traffic emission modeling for discrete time step and discrete road segment. Bigazzi et al (2011) model road user exposure to air pollution along a roadway. They found that exposure mitigation should focus on reducing the time spent in the roadway and reducing the volume flow of vehicles on the roadway and individual travelers can greatly reduce their roadway exposure by adjusting their departure time to less congested, lower volume periods. Arnott (1991) stated that information can cause drivers to change their departure times in such a way as to exacerbate congestion. Kim et al (2005) developed optimal driver attendance time, optimal departure times, and optimal routing to demonstrate advantages of using traffic information in terms of total cost savings and vehicle usage reduction as well as improving service levels for just-in-time delivery.

3. Conceptual Framework for Air Pollution Reduction

From an urban transportation planner's point of view, we would like to improve city walkability and reduce air pollution. However, from the drivers' point of view they want to reach their destination as soon as possible. As we provide the traffic information as tool for the drivers to navigate, we could not expect the drivers to inspect the information about air pollution and make decisions whether to travel or not based on the traffic information and congestion level.

Air pollution caused by traffic has local characteristics. Unlike air pollution from factories or dust from volcanic eruptions that are transferred by the wind up to hundreds of km, urban traffic air pollution severity reduces logarithmically by the distance to the road. The severity of air pollution on the road is high on the intersections where the vehicles stop. This happens due to high concentration of air pollution in the same space and the same time. As number of vehicles on certain road increases it contributes more pollution. Congestion and pollution are closely related. With subject to constraint of some environmental factors such as wind speed and direction, and the layout of buildings along the street, we can say the higher congestion leads to higher concentration of air pollution. Congestion level that is related to air pollution should be measured as traffic density rather than traffic flow.

We surmise that the amount of air pollution concentration in certain areas can be controlled based on certain types of traffic information that we call as green traffic info. Traffic information can play major role in informing the public on where is the best route to go. In our view, traffic information is a non-intrusive tool for the drivers to be guided into less congestion and less air pollution areas. As the drivers use on-board navigation to choose their best routes, the navigation system should be able to guide the drivers through less congested roads. We can utilize public trust on the traffic information to guide the drivers not only to avoid congestion but also to avoid highly concentrated air pollution areas. In addition to avoiding higher congestion level, the navigation system should be able to guide the drivers to areas where air pollution is less concentrated.

How can such information to guide the drivers reduce the air pollution? To control air pollution from transport, we need to distribute the amount of traffic density on the road network over time and space such that the air pollution will also be dispersed. Lower concentration of air pollution get easily blown away by the wind while higher concentration of air pollution take more time to be dispersed by the wind.

The role of the traffic information system is not only to provide the information of the current traffic condition in real time but also to predict the traffic flow, density and speed, and hence the congestion level as well as air pollution. Traffic information system is not a mere information provider but should also utilize traffic model to distribute the amount of traffic density on the road network over time and space such that the air pollution can be dispersed in shorter time. Knowing the amount of origin destination, we can make a model that will give not only traffic prediction but also best route suggestion in such a way to utilize more secondary roads than mere major roads. When the amount of traffic density can be widely distributed over space and time, the overall air pollution can be reduced.

4. Traffic Information Model

We model traffic information as a causal loop diagram in system dynamics as shown in Figure 2. The dynamic behavior of the traffic information model is described as follows. Higher traffic congestion increases air pollution level. An increase in air pollution level will deteriorate human health and increase the public awareness of traffic info. Higher traffic congestion also increases the public awareness of traffic info which eventually increases the usage of traffic info. Higher usage of traffic info decreases the traffic congestion. Lower traffic congestion means lower air pollution level and improves human health in general. Lower traffic congestion and the improved human health will decrease the public awareness of the usefulness of traffic info. The decrease of public awareness will decrease the usage of traffic info and eventually increase traffic congestion again.

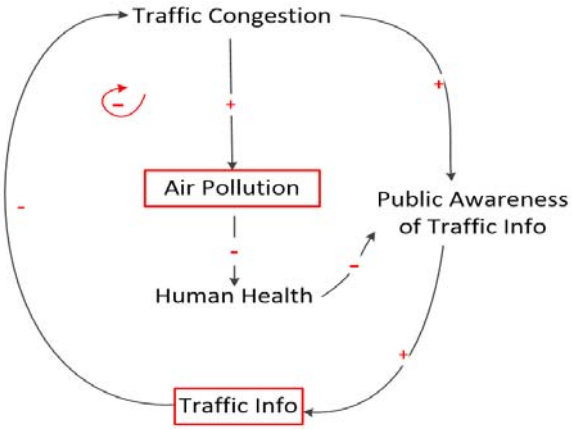

Figure 2. CLD of Traffic Information

5. Conclusions

The existing traffic information only provides a means for drivers to find a better route and avoid congestion or traffic problems. The existing traffic info plays a passive role only as information provider. In this paper, we propose a new conceptual framework for the traffic information system to play a more active role as a system that directs the traffic to reduce the overall congestion and reduce air pollution through traffic modeling and traffic monitoring at the same time.

The key to reduce the air pollution is to distribute the amount of traffic density on the road network over time and space such that the level of air pollution will also be dispersed. Lower concentration of air pollution gets easily blown away by the wind while higher concentration of air pollution takes more time to be dispersed by the wind.

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