Fuel Efficiency

New Mexico
Supercomputing Challenge
Final Report
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Team 10
Artesia High School

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Executive summary

By using the data we gathered from resources such as the internet, books, and articles, we attempted to find the most efficient traffic control system . Through the application of queuing theory to our project by modeling lanes and intersections as networks of queues and servers, we were able to identify the traffic system that consumed the least amount of fuel. We then assumed that the least amount of fuel used would produce the least amount of carbon dioxide (*CO_2, a significant greenhouse gas)* emitted. We then created a model, implemented in NetLogo and simulated two scenarios to examine the alternatives. Our group also gathered data on certain models of vehicles and their CO_2 output. From this information, we created three classes of vehicles ... one with low fuel consumption; one with intermediate fuel consumption; and one with high fuel consumption. We will model each Traffic regime in NetLogo, and view its (CO_2) emissions. Then we will base our conclusion on which Traffic System is the most effective in reducing (CO_2) emissions.

Problem Statement

When fuel is consumed, it produces a greenhouse gas called carbon dioxide (CO_2). Roadway intersections are built for safety and order, but they also have an effect on CO_2 emissions. Which traffic control regime is the most efficient in terms of fuel consumption where the options are a rotary intersection, an intersection with stop signs, or an intersection with stop lights? The problem of fuel consumption when the vehicle is idling is that it releases (CO_2) (a greenhouse gas). There are several ways traffic control systems have an effect on (CO_2) emissions. We want to find out which system would be the most effective in reducing (CO_2) emissions.

Why Is this project important

Fuel Consumption is said to disrupt the environment through the release of greenhouse gases such as carbon dioxide (CO_2) .Traffic control regimes such as traffic signals, rotaries, and stop signs have a big effect on fuel consumption, and (CO_2) emissions. (CO_2) concentrations in the atmosphere increased from approximately 280 parts per million (ppm) in pre-industrial times to 382 ppm in 2006. The current rate of increase in (CO_2) is about 1.9 ppm/v/year. Almost all of the increase is due to human activities. When fuel is consumed, it produces a greenhouse gas called carbon dioxide (CO_2). Intersections are built for safety and order, but they also have an effect on (CO_2) emissions. Which traffic control regime is the most efficient in terms of fuel consumption where the options are a rotary intersection, an intersection with stop signs, or an intersection with stop lights? The problem of fuel consumption when the vehicle is idling is that it releases (CO_2) (a greenhouse gas).

There are several ways traffic control systems have an effect on (CO_2) emissions. We want to find out which system would be the most effective in reducing (CO_2) emissions.

Prologue

Initially, our proposal stated: What is the most efficient way of conserving fuel at traffic lanes? A stop light, a rotary, or a stop sign? By the time the Interim Report was due, this simplistic statement had expanded to: Which traffic control regime is the most efficient in terms of fuel consumption where the options are a rotary intersection, an intersection with stop signs, or an intersection with stop lights? The problem of fuel consumption when the vehicle is idling is that it releases (CO_2) (a greenhouse gas).

Methodology

While NetLogo is relatively easy to learn, the logic of our program is based on Mr Bennett's ability to sequence complex ideas into relatively straight forward code. We could not have completed the project without him. One very important skill we acquired was to write with two very important tools: a classified thesaurus, and a dictionary. Every word was carefully parsed for synonyms and for definitions. Without learning this skill, our paper would be far more redundant and simplistic.

Planned Approach

Our group is going to find which Traffic lane is most efficient by using the data we gather from resources such as the internet, books, and articles . We are going to apply queuing theory to our project by modeling lanes and intersections as networks of queues and servers. We will implement this model in NetLogo, and simulate multiple scenarios to examine the alternatives.

Our group will also gather data on certain models of vehicles and their (CO_2) output. We will model each traffic system in NetLogo, and view its (CO_2) emissions. Then we will make a conclusion on which traffic system is the most efficient in reducing (CO_2) emissions.

Research

Carbon dioxide (CO_2) is emitted in a number of ways. It is emitted naturally through the carbon cycle and through human activities like the burning of fossil fuels. Natural sources of (CO_2) occur within the carbon cycle where billions of tons of atmospheric (CO_2) are removed from the atmosphere by oceans and growing plants, also known as 'sinks,' and are emitted back into the atmosphere annually through natural processes also known as 'sources.' When in balance, the total carbon dioxide emissions and removals from the entire carbon cycle are roughly equal.

(CO_2)is more than just the stuff that comes out of smokestacks, tailpipes, cigarettes and campfires. It is also a crucial element here on planet Earth, essential to life and its processes. It is used by plants to make sugars during photosynthesis. It is emitted by all animals, as well as some plants, fungi and microorganisms, during respiration. It is used by any organism that relies either directly or indirectly on plants for food; hence, it is a major component of the carbon cycle. It is also a major greenhouse gas, thus it is closely associated with climate change.

Joseph Black, a Scottish chemist and physician, was the first to identify carbon dioxide in the 1750s. He did so by heating calcium carbonate (limestone) with heat and acids, the result of which was the release of a gas that was denser than normal air and did not support flame or animal life. He also observed that it could be injected into calcium hydroxide (a liquid solution of lime) to produce Calcium Carbonate. Then, in 1772, another chemist named Joseph Priestley came up with combining (CO_2) and water, thus inventing soda water. He was also helped in coming up with the concept of the carbon cycle.

Since that time, our understanding of (CO_2) and its importance as both a greenhouse gas and an integral part of the Carbon Cycle has grown exponentially. For example, we've come to understand that atmospheric concentrations of (CO_2) fluctuate slightly with the change of the seasons driven primarily by seasonal plant growth in the Northern Hemisphere. Concentrations of carbon dioxide fall during the northern spring and summer as plants consume the gas, and rise during the northern autumn and winter as plants go dormant, die and decay.

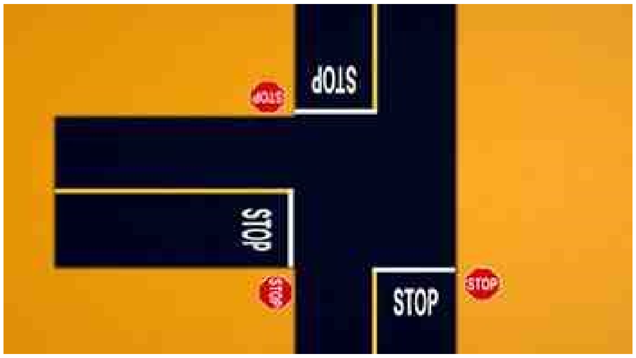
Traditionally, atmospheric (CO_2) levels were dependent on the respirations of animals, plants, and microorganisms (as well as natural phenomena like volcanoes, geothermal processes, and forest fires). However, human activity has since come to be the major mitigating factor. The use of fossil fuels has been the major producer of (CO_2) since the Industrial Revolution. By relying increasingly on fossil fuels for transportation, heating, and manufacturing, we are threatening to offset the natural balance of (CO_2) in the atmosphere, water and soil, which in turn is having observable and escalating consequences for our environment. As is the process of deforestation which deprives the Earth of one of it's most important (CO_2) consumers and another important link in the Carbon Cycle.

The function of any traffic signal is to assign right-of-way to conflicting movements of traffic at an intersection. Fine-tuning traffic signal timing can reduce traffic congestion, thus cutting short-run CO_2 emissions from traffic through the signalized area by about two percent. For more than eighty years, electrically operated signals have been used to control vehicular traffic in the United States. The earliest signals were manually operated. Police officers used "switch stand" type devices to change the red and green targets and lights. It was not long, however before simple automatic controllers were developed to relieve police officers of this duty. Since then, traffic signal control equipment has undergone continual improvement. The earliest signal controllers used motors and gears to time the durations of the signal indications, and direct descendants of these controllers can still be found in use today.

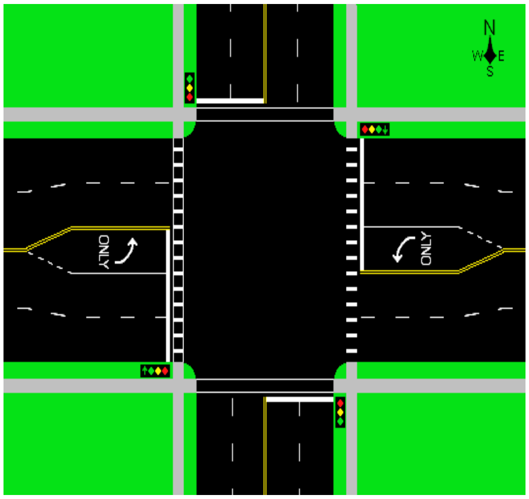
However, the revolution in electronics has brought microprocessor-based signal control equipment that is far more powerful and flexible than anything dreamed of just a decade or two ago.

Stop signs notify drivers to stop before entering an intersection and to give way to crossing vehicles. Stop signs originated in Michigan in 1915.The first ones had black letters on a white background and were 24 by 24 inches (61 × 61 cm), somewhat smaller than the current sign.

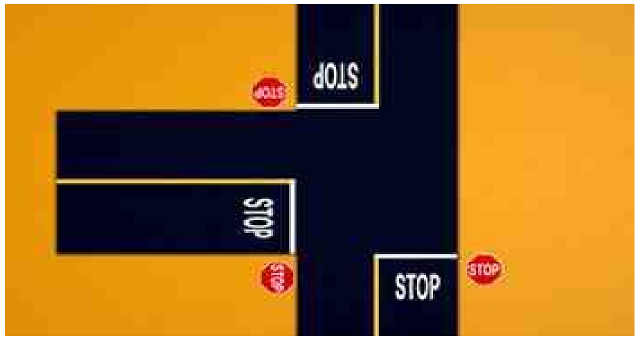
As stop signs became more and more popular around the world, a special Committee supported by the American Association of State Highway Officials (AASHO) met in 1922 to customize these signs. The committee selected the octagonal shape with the white lettering on red background that has been used almost all over the world since. This design was decide to be the best because it was the most visible and contrasted well with the surroundings.



Four-way intersections are the most commonly used traffic control regimes. They involve a crossing over of two streets or roads, in areas where there are blocks and in some other cases, the crossing streets or roads are perpendicular to each other. However, two roads might cross at different angles. Sometimes, the junction of two road segments may be offset from each when reaching an intersection, even though both ends may be considered the same street. The roads may sometimes wind into each other, but is till considered a four way intersection.



Three-way intersections with stop signs involve a straightforward proceeding road or street with one perpendicular road meeting the straight road. Unlike the four-way intersection, vehicles on the perpendicular road cannot proceed ahead, they either turn left or right. The only control signal that is used is a stop sign that does not change in certain timing; a stop sign stays the same. The vehicles on the perpendicular road are required to stop on an average of one minute in order to wait for the straight road vehicles to proceed their way.



Traffic circles or rotaries are a circular intersections where traffic travels in one direction around a central island. The first rotaries were used in Europe; France, in particular, to control the dense traffic of the cities and towns.   French architect, Eugène Hénard, invented the first one-way circular intersection as early as 1877 . American architect, William Phelps Eno, favored smaller traffic rotaries. He designed New York City's famous Columbus Circle, which was built in 1905. Other circular intersections were subsequently built in the United States, though many were large diameter 'rotaries' that enabled high speed merge and weave maneuvers, easier in high traffic areas.

Roundabouts differ from rotaries They are traffic circles, but they require vehicles to stop and wait for previous cars to proceed. The first roundabout in history was built in Letchworth Garden City, England in 1909 - originally intended as a traffic island for pedestrians. In the early 20th century, numerous traffic circle junctions were constructed in the United States. They were especially common the northeast states. They allow entry at relatively high speeds and require entering drivers to weave with exiting and circulating traffic. Roundabouts are more widely used because they have better qualifications for safety laws.

Code

As you already know we used NetLogo to model our project. The type of code we used was c++ modified. We used our code in every aspect of our model even though we did not learn it completely we worked hard on the model with our programming mentor Nick Bennett. We found that NetLogo was not as easy as it looked. We had a lot of fun modeling though and hope to learn a lot more code.

Results

Our results through observation of traffic signals,rotaries, roundabouts, and traffic behavior are that rotaries are more efficient at conserving CO2 emissions. The reason for these results are that when at a rotary you do not have to stop and allow your vehicle to idle there for there is less CO2 output. Our model also supports are results by showing how long it takes to idle in traffic intersections and roundabouts. The longer a vehicle has to idle and wait for traffic lights, stop signs, and yield signs at roundabouts the more CO2 the vehicle puts out. Through research we have also found are results to be true.

Conclusions

Our team's conclusions are that a traffic signal, a three way intersection with a stop sign, and a roundabout are not the most efficient in conserving CO_2 output into the atmosphere. Through careful research, observation, and modeling our hypothesis with Netlogo we have came to the conclusion that a rotary is the most efficient way in conserving CO_2 output into the atmosphere. This conclusion comes from careful consideration by observing all traffic regimes and using basic problem solving skills through modeling, research, and observation.

Software

- NetLogo 4.1.1
- Open Office Writer 3.1
- Open Office Draw 3.1
- Microsoft Powerpoint 2003
- Open Office Impress 3.1

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