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Since the existence of horse-drawn carriages, there have been traffic signals to guide them throughout the roadways (Regenold). Traffic signals have come a long way, but they have always existed to enhance public safety and reduce congestion (Kent 9). Throughout the decades, there have been many improvements in the development of traffic signals, and today, there are a variety of vehicle detection systems in place to help manage regulated traffic more efficiently. No single type of detector is perfect, however; respective advantages and disadvantages pertain to each type of detector presented herein: the pneumatic road tube, the inductance loop, the ultrasonic sensor, the video camera, microwave radar, and infrared sensors. Current standards and practices vary between each of these detection systems just as strikingly as the mechanical principles that allow their operation. Similarly, different areas and regions rely more primarily on certain types of vehicle detection systems than others.

Horse-drawn traffic was managed by mechanical devices called semaphores. Semaphores are "tall posts with moveable arms" with lanterns on top, and were hand-operated by policemen to enforce commuter obedience (Regenold). At night, a green lense was placed outside of the lantern to indicate a "go" signal. and a red lense was used to indicate a "stop" signal. One immediate and widespread problem was that visibility of such devices was low at congested intersections or during peak hours, due to the fact that the semaphore was on ground level. The apparent solution was to raise this same device up into the air into a tower in the middle of the intersection, where the colored indicators (or semaphore arms, otherwise) were more visible to commuters. The first four-way, three-color traffic signal was invented and used in Detroit, Michigan by William L. Potts, a Detroit police officer, and in the 1920s, the automated traffic signal was invented which used preset timings to activate its indicators (Regenold). Yet, even with the newly invented four-way, three-color signal, automation was still very much an issue, with inordinate waiting times becoming frustrating for drivers. Over the upcoming decades, many new devices were invented to try and cut down on the timing aspect of the traffic signal: one invention, created by Charles Adler, Jr., sensed when a driver honked his or her horn, and would flip the signal to green to allow passage, respectively. Another invention, created by Henry A. Haugh, sensed the pressure of a vehicle before the traffic signal: two metal strips made contact under the vehicle's weight and sent an electrical signal to the traffic light in order to let the vehicle pass. In 1935, the printing of the Manual on Uniform Traffic Control Devices had the colors of the lenses standardized throughout the country. These colors have remained constant and are the same now as they were then: red for stop, yellow for caution, and green for go. Even today, many intersections are regulated by pre-timed traffic signals (Regenold). In recent years, new advances in technology have allowed a reduction in traffic congestion by improving upon the signaling automation process.

The reduction of congestion and the minimization of wait times has long been the driving factor in the development of automation regulators. To assess congestion, there exist a number of techniques to count the vehicles traveling on the road. Sensors built into the road are known as intrusive sensors, while sensors toward the side or above the road are known as non-intrusive sensors. One very old method, which is sometimes still used, is to manually count the cars and time how many cars pass by in a given amount of time. As a time consuming and tedious process, this has been largely relieved by the pneumatic road tube sensor. Road tubes send out a small burst of air when a vehicle rolls over them, which closes an air switch. The closing of this switch, in turn, sends an electrical signal to a machine which counts how many signals it has received, and then deduces the number of cars on the road. The advantage of this method of counting is that it obviously requires less manpower to perform than manual counting, and that the road tubes can be deployed quickly for permanent or temporary applications. Some disadvantages are that the road tubes are subject to vandalism and, therefore, malfunction, and that there can be inaccurate tire counts when large trucks or buses with more axles roll over them during busier hours (Kent 25-7). After assessments are made as to how much traffic is coming through a particular roadway or intersection, decisions are made regarding signal automation.

"The inductive loop detector (ILD) is the most common sensor used in traffic management applications" (Kent 40). It observes the presence of vehicles on the road, commonly seen at intersections in the Houston area. The inductance throughout the loop is lowered when a vehicle passes over the loop. This decreased inductance sends a signal to a controller, which then realizes a vehicle is stopped at, or has passed over, the inductance loop. As such, the inductance loop can be used to tell a traffic light that a vehicle is waiting to proceed through the intersection and, if no other traffic is around, the green signal can be given to the motorist. Advantages of this technology include detecting "volume, presence… [and] speed", not to mention that it is considerably cheaper than alternative means of vehicle detection (Kent 41). Drawbacks to this type of detector revolve around the installation process – traffic must be temporarily blocked and the concrete must be in a suitable condition. Still, the inductance loop offers a variety of uses besides vehicular presence at the intersection: vehicle counting, vehicular passage, and even vehicular classification (Kent 40). While being a widespread tool, other advances in technology are encouraging the use of more non-intrusive sensors (sensors not built into the road) (Kent 16).

The ultrasonic sensor is mounted horizontally off to the side of the road or from above (aiming downward) the road, and emits pulses of energy that create two beams which measure the speeds of vehicles that cross them. This device works by measuring the time it takes for the pulse emissions to reflect from the vehicle and return to the emitter. Two main advantages for this sensor's usage are that no traffic needs to be blocked for road installation, and that multiple lanes can be covered by a single unit. This, therefore, reduces the error in traffic counts while simultaneously monitors more of the traffic for speeders. Unfortunately, atypical temperature and weather conditions as well as high-speed traffic can have adverse affects on the accuracy of data gathered by these sensors (Kent 196).

Video cameras are becoming more widespread as traffic control devices. Many older video cameras send data to human interpreters, but newer camera systems, known as video image processors, have built-in software to automatically detect vehicles and conduct traffic flow. The automated processors work by constantly comparing new video frames to previous frames of footage, usually interpreted in black and white. In some systems, the grayscales of the images are compared against themselves for edge features between frames, and any incoming vehicles can be distinguished from the scenery and observed for speed and classification. If traffic flow is moving slowly, the cameras can send information to alert drivers down the road of the delay. A main advantage to using the processors is that one video image processor can replace multiple inductance loops and span several lanes. Disadvantages include tall trucks which may obstruct other cars from visibility, and image obscurity due to condensation, heavy rain, fog and even perched birds. Cameras are also subject to vandalism (Kent 136).

Having been developed during World War II, microwave radar technology is an older method of object detection which is has been adapted for traffic regulation and monitoring. A beam of energy is emitted toward a space of roadway, and when a vehicle travels through it, part of the beam gets reflected back towards the antenna and strikes a receiver, where occupancy, speed and vehicle count can be measured, depending on the type of emitted waveform. This type of detector can be used in a variety of methods, including traffic monitoring across multiple lanes, single lanes, or to detect vehicle presence, depending on the placement of the microwave radar unit relative to the road. Microwave radar units can give very accurate readings relating to the speeds of vehicles, and can endure poor weather conditions better than most other vehicle detection systems (Kent 155-61).

By contrast, infrared sensor operation can be problematic through inclement weather. Despite being used for signal control, weather events such as freezing rain, snow, haze, and even "glints of sunlight" and cloud shadows can cause problems with vehicle detection and may confuse the traffic signals. This is because infrared sensors work by detecting infrared radiation, which is interrelated with the transferal of heat.

Active infrared sensors transmit energy of their own; they send out infrared beams which get partially reflected back from a targeted zone when a vehicle drives through it. These reflected packets of energy get collected by a receiver and recorded. Another type of infrared sensor, known as a passive infrared sensor, does not send out beams of infrared energy but, instead, collects only the infrared energy that is naturally reflected in the targeted zone. These detectors may contain many "energy-sensitive detector elements on the focal plane that gather energy from the entire scene" (Kent 172). Any object emitting a non-zero surface temperature gets received and recorded by the sensor. Regardless, infrared sensors can distinguish between multiple types of vehicles, yield accurate readings for speed and position, observe multiple lanes simultaneously, and they regularly serve to control traffic signals (Kent 170-75).

In the city of Houston, most detectors are either inductance loops or video cameras (video image processors) (Maddox). "Both detection systems are reliable and the difference in cost does not play too much of a part these days" (Hooper). Inductance loops are a reliable choice due to their longevity, if properly installed. Poor concrete conditions can keep inductance loops from lasting. Conversely, video image processors are very reliable but can slide out of focus from wind gusts or from poor calibration. With good concrete conditions and steady weather conditions, the decision to use video image processors or inductance loops is largely left up to personal preference (Hooper).

Since the birth of modern transportation, traffic signals and their automation have been crucial to the motions of traffic. Many different types of vehicle detectors with many different types of designs exist out on the roads today, from microwave emitters to simple pneumatic tubes. Though they may vary in design and application, each different type of detector is engineered to help reduce traffic congestion and increase public safety.

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