Parking Lot Checker

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Introduction

The purpose of the parking lot checker is to provide a visual representation of where available parking spaces are in a parking lot. The main goal is to have an accurate and practical source that someone could check before they arrived at a place that has our system implemented. It has the ability to identify both empty and full spaces in any parking lot that is being monitored. The main interface would be through a website which has a login page and then allows the user to select which parking lot they wish to park in. It then displays a screen shot of the current status of that parking lot.

Target Audience

There are a wide range of potential customers for this project. Any institution that has a parking lot/garage that is larger than a few dozen spaces would benefit from our system. It would improve their customers' satisfaction by providing a convenient and accurate representation of when spots are available. This would especially be useful for an employer that has multiple parking lots spread out over a wide area, like Iowa State University. In this case faculty members typically purchase a parking permit that allows them to park in designated lots. But there is no guarantee that there will be an available parking spot in the lot nearest to the building where their office is. If they could check something on the way to work that shows them which spots are available in that closest lot, or in the nest closest lot, it would save them time, money, and it eliminates the frustration of having to try to find a spot on their own. Another practical scenario would be when someone enters a parking garage. At the entrance, where they have to stop to take a ticket, there could be a monitor that simply shows a visual representation of the entire garage, with the available spots highlighted and summarized. This way someone would know that there aren't any spots available until they are on level 3, for example.

The other main potential customer would be the consumer. When an employee is evaluating the parking permit options with their company there may be a standard permit they could purchase. Or there may be an optional upgraded package that comes with access to the monitoring system. This would allow them to see the available spots in any lot their permit allows them to park in. It's not hard to imagine our project expanded a little bit so that it could be integrated with direction finding services. This would allow people who have GPS units in their cars to not only get directions to their destination, but also see what spots are available for them to park in.

Need For This Device

There seems to be a glaringly obvious need for a product like this. It seems natural that as technology becomes cheaper and customers are demanding more that something like this would make sense. It is typical that parking garages have cameras in them for security reasons. This shows that operators aren't afraid to implement modern technology in a seemingly archaic device. Probably the biggest reason this would be useful is because it takes the frustration out of the person looking for a parking spot. A common scenario is that someone is running late for work, so they are already frustrated and in a bad mood, but then adding on to that they have to

drive up and down every isle to try to find an open spot when they get to work. Our product would benefit the frustrated customer in the following ways:

- Saving them the time from driving up and down each isle
- Saving them money from wasted gas
- Reducing their risk of accident

It's obvious that our system would be of large value to someone who doesn't leave very much extra time during their morning commute. But it would also be very beneficial for lowering stress levels for everyone.

Related Work

It is becoming fairly common for large parking lots to incorporate some sort of simpler inventory system. This is usually implemented by having gated access to the lot. This way there can simply be a counter built into, or connected to, the gate so that every time an entrance gate opens the running total is increased by one and every time an exit gate opens it is decremented by one. There are also parking lots that accomplish this same running total by some other means besides gated access. It is possible to have a circuit basically built into the concrete at the entrances and exits to a parking lot. When a vehicle drives over this area it affects the magnetic field of the circuit by closing the connection. This circuit can be connected to a simple computer to do the counting for the parking lot. Systems like these are only able to tell the customer if a parking lot is full or not, there is no possible way of indicating where available spots are. Systems like these also are not as practical because the customer is already at the entrance to the parking lot before they find out that it is full. These are also easily fooled by people driving around the gates, or by entering and exiting the parking lot from some place that is not the official entrance or exit.

Previous Experience

We have experience working with most of the technologies used in this project. We had multiple homework assignments in cs401 that involved using openCV to analyze and manipulate video files. These homework assignments gave us enough initial experience using openCV to get started on our project.

Wilson is a senior in Computer Engineering. He is most experienced with C++ and lower level programming. His experience with his senior design class helped with the motivation for choosing our topic.

Nate is a senior in Computer Science. He brings lots of experience with dealing with user interface design. He is most experienced with programming in C++.

Jeff is a senior in Computer Science. He has a unique background of classes under his belt including cs472. His insights helped to figure out how our program should act under less than idea situations.

Equipment

For this project we used multiple webcams that were mounted so they had clear views of sections of parking lots. We used one of the computers in the Pearson lab to record time segments of the parking lots filling up. We used these same computers to do our programming and testing on as well.

If someone wanted to implement our system they would most likely need multiple cameras per parking lot. The reason for this is because for our system to work it needs a fairly straight forward view of the stalls, and they cannot be obscured by any other obstacles. For the most ideal situation a camera could be placed from a bird's eye view and see the entire parking lot from above. Unfortunately the logistics of this make it almost impossible to happen. The camera would need to be mounted extremely high, and in the center of the parking lot, to see all of the stalls. This would not be very visually appealing and also the further away the camera is the more likely something will obstruct its view. They would need each of these cameras to be on a network together and accessible by their main computer. They would probably want this computer to be at least reasonably fast, but no extreme hardware would be required. This computer would do all of the processing for the cameras which are attached to it.

For a customer to use our system they may not need any extra equipment. If it is deployed on a parking garage where they have to stop at the front to pull a ticket and go through a gate there could be a monitor there showing where the available spots are. If the parking lot is one that does not have gated access the simplest method for a customer to find available parking spots would probably be the integrated website. This could be something that they could check from their cell phone on their way to work, or if they have a short commute they could check it before they leave for work. The only thing that a customer would need for this would be their access code, if it were setup as a pay service.

Data Structure

In order for our system to work there is some setup that an administrator needs to do to configure a parking lot so it can be monitored. First they need to propagate the internal data structure of the parking lot they are working with. They will need to know how many spots are in the parking lot and what the geographical configuration of them looks like. This is something that basically has to be done manually because there is no reliable way to automate it. The way our program stores this parking lot information is in a class called "parking_lot." Once a "parking_lot" is created the administrator must add the correct number of stalls to it using the built in class functions. They must then determine and enter where each stall is so the computer knows where to look for movement.

After the data structure is configured on a per parking lot basis the system needs to be setup to work with the website. This is simply a matter of configuring Apache to display a certain webpage that is designed specifically for that parking lot. Once this initial configuration is completed the system will mostly run on its own. We designed it so that after the initial setup is

done there theoretically will not need to be any administrator interaction for a very long time, assuming no hardware failures happen.

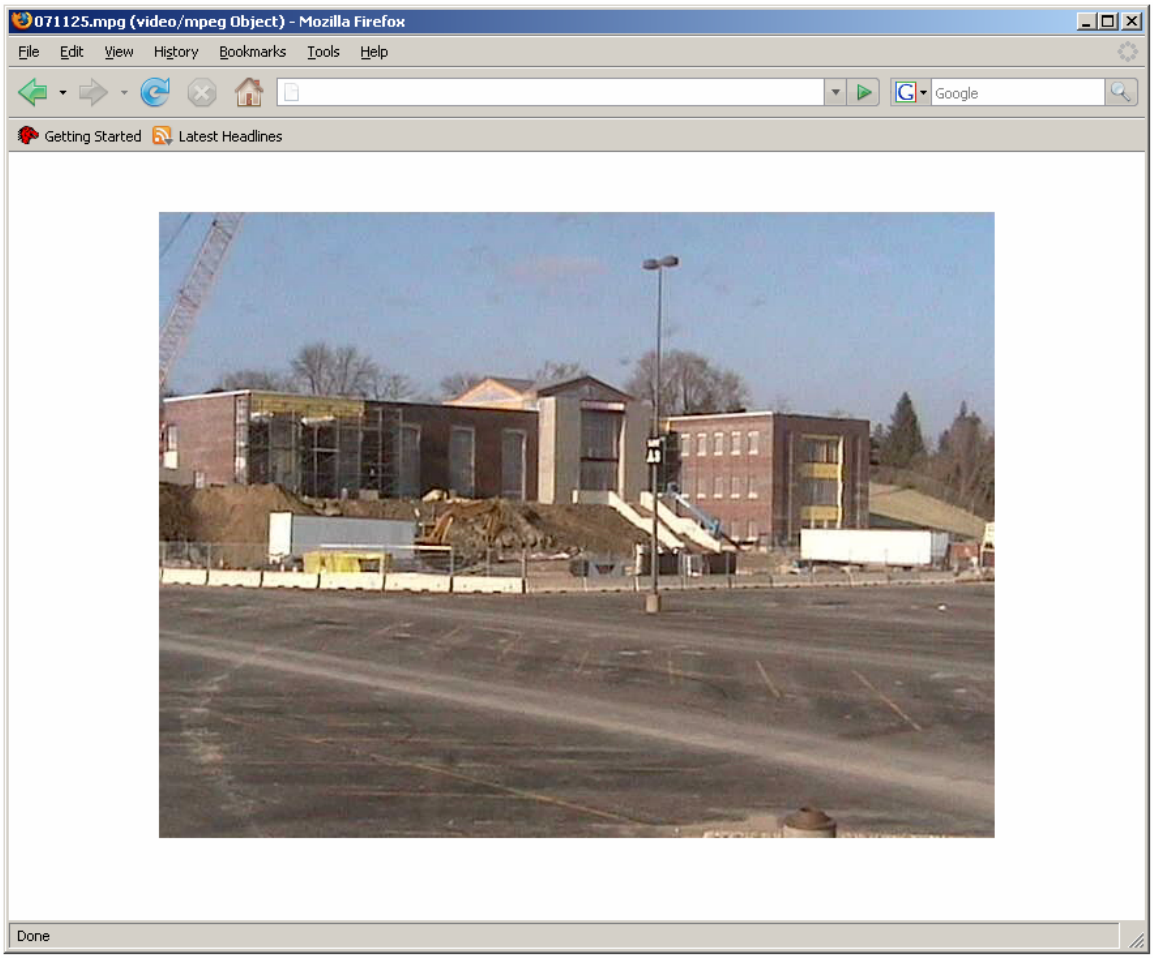
Algorithm

Once the particular parking lot information is entered into the program the logic used is fairly simple. There are a certain number of predetermined stalls in a parking lot. In each of these stalls we use openCV to draw rectangles for movement detection. Everything else in the field of view is removed. We then call the motion detection function to determine if there is any movement it the stall. This will tell us that a vehicle has moved into the current spot. It will still scan a stall after a vehicle has occupied it. Once it detects movement again in that stall it knows that the vehicle is exiting the stall and it will mark it as unoccupied.

We experimented with the size of the rectangle that would be drawn for each stall. We found that if the rectangle in which we were detecting movement in was too small that it would have more false positives. There is a parameter that we passed to the motion detection function that says what the minimum size is. This helped to weed out false positives. It was also helpful to make the rectangles slightly smaller than the actual size of the stalls. This eliminated some problems with people parking over the line. We did explore other options to our algorithm. One that we tested was using multiple motion detection squares per stall. This mostly just complicated our code and led to unpredictable results

User Interface

One possible display would be when someone enters a parking garage. There could be a monitor setup to display the current status of available spots in the garage for everyone to see. The most probable method that someone would access our system would be from the website that is monitoring the parking lot. This is fairly simple; it contains a menu that has multiple parking lots if more than one is being monitored. But functionally, some one would select the parking lot they are curious about and it would display a screenshot of the video that clearly has each parking space marked as either available or not available. This is a sample screenshot of what a user would see when they go to the website to check the status of the parking lot the wish to park in.



Limitations

Our main limitation is camera angles. In order to accurately detect vehicles the cameras cannot be obscured by any objects. This includes trees, buildings, and many other variables. Having good viewing angles also helps reduce the effects of glare. We had some problems from videos that were taken early in the morning because the sun was glaring off windshields and causing inaccurate results. Shadows also proved to be a fairly limiting factor as well. If we tried to use time lapse videos that were moving too fast our system would detect shadows from buildings and other objects as vehicles. To get around these limitations we used cameras that are closer to the stalls they are monitoring. Doing this improved our results drastically. Some factors could not be avoided. Unless the parking lot is extremely well lit our system is not effective at all at night. One possible solution to this might be using infrared cameras, but testing that was not in the scope of this project.

Another potential problem could be snow. We did not have an opportunity to test our system on a parking lot that received snow fall. We expect that it would most likely have sporadic results when the parking lot is completely snow covered. This is because without seeing the stall lines people will not be able to tell where they should park and will most likely be outside the boundaries of the stalls. Our system would still be looking for cars that are parked within the

designated (now invisible) lines. This would probably cause most spaces to be only partially filled, but our system would represent it as both stalls being occupied.

We also ran into some problems with our website. These were mainly just a factor of us running out of time. But we would have liked to have more advanced features available on it.

Evaluation

For the purposes of this project we tested our program on prerecorded videos. This made it significantly easier for us to test small parts of our program. It was also convenient because we already knew what the end result should be, we didn't have to wait for cars to come and park in a parking lot we were monitoring.

In an actual implementation our program could work with a real time system. As long as the cameras that are monitoring the parking lot can output video directly to our program in the correct format there are no foreseeable problems.

We tested our system by first defining a small section of a parking lot that has more ideal viewing angles. This made implementing the base more convenient for us. After this was successful we switched our system to monitoring a larger section of the parking lot. We did not try to cover too much of the parking lot because it is unrealistic to expect one camera to be able to catch everything. We decided that it was more important to have accurate results than to try to cover more area then we realistically could.

We did test our system on some other videos that had less than ideal viewing angles and other problems. For the most part the results were what we expected. This means that any place that our system is deployed to would have to pass some initial conditions if they want it to be successful.

Future Work

One thing that would be realistic to improve with our project is refining the webpage. Having it setup with more advanced features such as a java applet version so that that cell phones can view it would greatly add to the practicality of it. Also adding things like access control and a menu system that lets the user pick between different parking lots would be nice upgrades.

Along those same lines we think a reasonable expansion of our project would be implementing it to work with websites like maps.google.com and www.mapquest.com. This way someone could maybe get directions to a stadium and then also see what sections of that stadium have open parking spots.

We would also like to see smaller improvements to the overall system. This may include features like a more robust data structure. We would also like to have some sort of solution to the glare and shadow problems that we encountered. These could probably only be fixed by upgrading the cameras and using a more advanced algorithm.