Problems Associated with Interior Car Cleaning and Exploring a Self-Autonomous Solution

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ABSTRACT

Self-autonomous mechanization is found throughout our lives nowadays impacting lifestyles, and the economy(J.F,2019). This sudden trend has touched almost every industry but one industry in which it could aid a lot is the car interior cleaning industry. Car messes are a big problem for many people as they increase risks for car owners and make their own vehicles a danger hazard in the process. Trying to sustain a clean car is an extremely formidable task for many car owners especially those who own pets due to them shedding fur, There are also many other people with the same issue ranging from car rental owners to parents of young children. (C.M, 2022). To combat this, the research paper unfolds the existing problems with modern solutions such as car detailing and vacuuming and proposes a product that can help solve many problems associated with car interior messes. The product is a self-autonomous vacuum made by the researcher called the Cobor which utilizes innovations such as biomimicry textiles such as gecko adhesion, cyclone vacuum flow, and many others to satisfy the plethora of overlooked demands of the majority of car owners while being efficient and practical in the process.

Introduction

One of the biggest difficulties for car owners, especially those who own pets such as dogs and cats is messes in their cars. The first reason why a car may get dirty is due to a prolonged period of time just utilizing it; this can result in messes containing junk food bags, plastic water bottles, tissues, etc, which is more than enough to get it dirty enough to the point where it may be interfering with the car owner's driving experience as well as opening the door to very dangerous risks. A published study from Princeton University written by Michael Blanding (2015) also states that having a messy workplace often leads to distractions and an overall lack of focus on the primary task. In contrast, a tidy car will lead to the owner having a happy mind as well as a lack of distractions, so they can spend their full focus on driving, which is recommended for their safety as well as others.

Casual messes are not the only problem, compared to other car owners, pet owners are one of the few groups of people that struggle the most when it comes to car messes. When a dog or cat enters the car they are bound to shed a lot of fur and over a period of time, this can become a significant interference in the previously discussed topics. Furthermore, pet fur, dust, and any after-effects of pets overall can be disruptive in the car for a plethora of reasons. One of the reasons is that it can cause allergies and overall worsen the air quality within the vehicle which can play a crucial role in a driver's respiratory health as well as the passengers. Not only that, messes caused by pets as well as owners could be breeding grounds for countless amounts of germs and bacteria which in turn can cause food poisoning or even just damage your immune system(Martin, 2023).

Although the current solutions for these problems such as vacuuming and car detailing are either impractical or time-consuming and it may seem that there's no hope for this problem there is one possible solution. This solution which is produced by the researcher is a self-autonomous car vacuum called the Cobor which is a portable car vacuum that can clean the car when the owner is not there making it relatively practical and time-efficient as compared to alternate solutions such as car detailing and vacuuming. In simple terms, all the owner has to do is put it in their car,

and by the time they come back it will be clean. There are a plethora of reasons as to why this concept can greatly help others and it will be discussed in this paper. In total, it can collectively save thousands of hours if not more for car owners. The ultimate goal of this study is to explain how this product can help and how its concept works.

Problems/Limitations for Current Solutions

Car Detailing

As of right now one of the current solutions to this predicament mainly caused by pets as well as humans in general is car detailing. The problem with this century-old solution is that it has become impractical to many car owners due to the prices revolving around unnecessary pricing for unnecessary detailing. For example, as of right now, car detailing for the interior of the car costs around 100 dollars (Spedden, 2023). Say that the average car owner goes to the car detailer about once a month which is recommended (Martin, 2023), Over a year the costs will add up to a staggering 1200 dollars. Even when you reduce the price to only half the amount you still end up spending 600 dollars a year on car cleaning which only adds up over the course of multiple years. The reason why this is so problematic is that consumers really just want a presentable car and are not willing to pay for detailed cleanings such as the undersides of their seats and all the corners of the car because it's simply not needed which is why most people don't even go to car detailers. In a poll taken consisting of 15 randomly picked car drivers who were asked which they would prefer and here are the results.

Specific Demands for Interior Cleaning

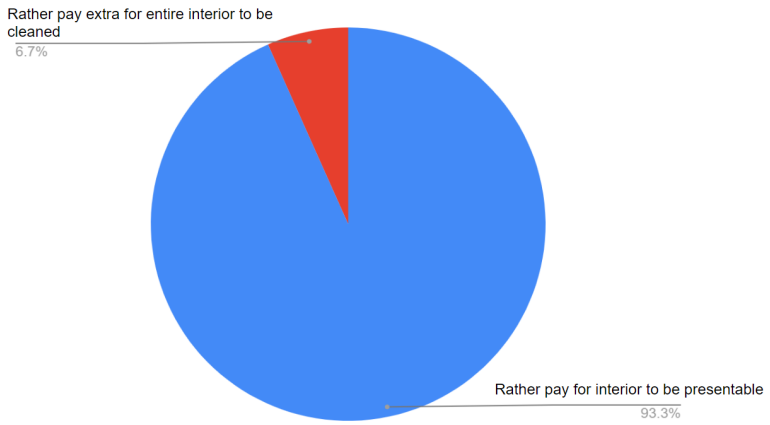

Figure 1. Red shows how much people are willing to pay extra for their entire car to be cleaned while blue shows the amount of people who want to pay just for their car to be presentable

This image further states the obvious that most car owners are far more willing to pay for their car to simply be presentable rather than paying extra for their entire car interior to be cleaned (Bessen, 2017). Now that it is evident why car detailing may not be a good solution for most people, one may ask, "If consumers are only willing to pay for what they want cleaned, why can't car detailers just clean less and charge relatively less for that?". The reason is because it's not an efficient business model. This is because car detailing consists of human workers who need to be

paid full time for cleaning their car, and if the costs were to somehow go from 50 dollars, which is already low, to 20 dollars to clean the surfaces and just make sure the car looks tidy, not only is this already undermining the skills of workers by making them do something that anyone can do, but it will also significantly decrease the revenue of the company as a whole. This in turn affects the worker's salary drastically, ultimately ending up in them leaving because there is no need for people of their expertise and they are getting paid in such low amounts that it won't be enough to sustain their family (M.R., 2004). In addition, car detailing companies have long wait times, with some having wait times that are over two weeks long. Adding on, car detailing services require customers to schedule appointments and leave their car at the dealership for a while, which is why many people don't turn to car detailing services because a lot of them are too busy to schedule and have to be at other places with their car rather than giving it to the dealership to clean it for over an hour. Overall, for people who want their car cleaned but don't have the time for it, car detailing is not an optimal solution because most people just want their car to be presentable, and car detailers do more than that and charge extra, making it impractical for the majority of car owners.

Self-Car Cleaning

The second solution for car messes is cleaning done by the owners themselves, such as vacuuming, wet wipes, and the list goes on. According to an interview taken with 15 car owners, around 5 of them have been notified that they vacuum the car for themselves every now and then. They said they have done this to avoid paying too much at the car detailers. They also listed some of the problems associated with vacuuming. One of these problems is time. Time is arguably the biggest problem in the world, and many modern-day innovations are solely based on helping consumers with time, such as high-performance laptops, which many pay extra money for because they save them time, the one resource that people value the most. When vacuuming the car, the subjects reported that they don't vacuum it often since it wastes their time and they could be spending their time on more important tasks such as raising the family, earning money, and more. Even when vacuuming, they reported that it's very laborious for them to vacuum their pet's fur because the pet's fur embeds itself into the fabric due to its oil. Six subjects went out of their way and stated in the interview that they knew many friends and family members who were too busy to clean their cars and had messy cars. Another traditional method of cleaning that owners use is chemicals and wet wipes. The problem with chemicals is that many car owners may use them on any stain in the car when they really should be used for only specific stains. Owners do this to save time and because they don't have the knowledge of how to use those chemicals. This may result in the chemicals damaging parts of the car, such as the leather, if it is a car with leather seats, or even the fabric of the car, which may not be visible at first but over time will have big effects overall, ruining the feel of the car because the seats are too uncomfortable and the hard floors will be visible due to much of the fabric being removed. The next thing that people use is wet wipes. Backed up by a research paper conducted by researchers Zhang, Y, and a couple of others (2021), wet wipes are said to do the job in car interior cleaning however, there is already a big crisis due to many of them contributing to global plastic pollution. Specifically, wet wipes have contributed immensely to the leakage of microplastics in the ocean, even penetrating unapproachable areas such as the Arctic. Suaria et al. (2020) collected approximately 1000 samples from six individual ocean basins, and the result of their study was that 99.7% of the samples contained microfibers such as synthetic fibers which originated from wipes. Even if wipes were to end up not being a problem for cleaning the car as a result of companies attempting to create biodegradable ones, it can still be time-consuming to use them. To rephrase what this paragraph is trying to say, traditional self-cleaning methods are not efficient solutions to cleaning the car interior because many people are too busy to clean their car, and those who still do would much rather have their car cleaned without wasting their time and negatively impacting the environment as well as their wallet.

Problems with All Alternate Solutions as A Whole

Now that the independent problems of both car vacuuming and car detailing are discussed, Let us look at the problems that they both share. The number one problem with these two solutions is the frequency with which the car gets cleaned. Many car owners, after cleaning their car, either spend their time cleaning it themselves or pay $100 for it to get detailed, and end up having their car become dirty again, especially pet owners. In fact, 15 randomly selected car owners who also own pets have stated that they don't like vacuuming or car detailing because their car ends up dirty right after, especially when their pet goes in the car. If they were to actually pay for car detailing every time their car gets dirty, let's just say the price for the detailing is only 20 dollars which is really generous and their car gets dirty within a week. In a year, pet owners would spend a staggering 1040 dollars just to keep their cars clean. Even when it comes to vacuuming it becomes a problem as well. Say that it only takes a person 10 minutes to clean their car's mess once a week, which is a big exaggeration since most people reported spending more time cleaning their cars in a week. The amount of time you would spend in a year just cleaning the car is 520 minutes, which is also almost 9 hours spent on car cleaning. This is not actually too much, but if they were to have a chance, subjects agreed they would not spend time cleaning their cars. What the majority of the subjects in the interview reported needing was something that was cost-efficient and would not waste too much of their time, such as vacuuming the car themselves as well as cleaning the car frequently so the car doesn't end up being dirty between cleanings. That's why this research is based on the Cobor, which can fill all these needs (Aryza, S., 2018; C.I., 2018).

Target Demographic

To first understand the demographic that Cobor can help, here are the current solutions and their limitations for existing problems in the car interior space. Car vacuuming done by the owner saves money and is somewhat customized to the owner, meaning they can clean as much as they want. One of the problems is that it is time-consuming, and the owner may not have the proper tools to vacuum it well. Car detailing is another solution that can save time, but a big problem is that it may be expensive. A problem they both have is that they are not done frequently, so the car gets dirty between cleaning sessions. So the needs that have not been satisfied so far are that there are no current options for car interior cleaning that can be done frequently, save the owner time, and be cost-effective. Many car owners have this need, but the biggest are pet owners. Pet owners, as previously discussed, have the biggest issue in terms of car interiors due to their pet's fur. This is because animals such as dogs shed a lot of fur, and if they get in the car, they may cause a mess immediately, this problem only gets worse with big dogs. Another problem with pet fur is that it is a formidable task to take it out of the fabric because it may be interlocked within it. This is why car detailing companies charge more to remove pet hair, as one of the 15 subjects in the previously discussed interview stated. When talked about in the interview, a majority of the subjects stated that they would love to have their pet stay in their car, but they don't allow them because they get the car dirty. When asked what they would do if there were a self-assembly vacuum that would clean up the mess, they all said that they would let their furry friend stay in their car. That's why Cobor is well suited for them, thanks to its ability to clean their car whenever they're gone and achieve their goal of making the car interior presentable. The next demographic with somewhat the same issues is car rental company owners. Car rental company owners have a lot of cars, and out of all people, they are the ones who need to clean their cars the most frequently. Usually, car rental companies have to clean their cars after every use to make sure they look presentable to the next customer. Since cleaning their cars is a big part of their job and they are spending a lot of time and money on it, Cobor could help them a lot, if not the most. The researcher conducted an interview with a car rental company owner, and he informed him that car cleaning is one of the biggest parts of car rental companies, and he takes time to vacuum the car himself instead of taking it to a car detailer because he would have to spend at least 1000 dollars a week, and it's also impractical because he just wants the car to be presentable after each visit. The main reason car rental company owners want their cars to be presentable is due to customer appreciation. In an effort to understand the effect of car presentability on customers, a survey was conducted by researchers on 228 customers (passengers) of car rental companies in Calabar Metropolis. The findings revealed that the cleanliness of vehicles had a significant positive relationship with customer satisfaction of car rental companies (J.A., 2022), concluding that there is a strong

correlation between car cleanliness and customer approval, which is why car rental companies value car cleanliness to a great extent. The last group of people from whom the Cobor may benefit are essentially those who have frequent messes in their cars, such as parents who have babies that may make messes as well as people who transport plants, and the Cobor can help them a lot as well as save them time by simply being placed in the car and the mess will be done by the time the owner comes back. To sum it all up, the self-autonomous car vacuum, aka the Cobor, can help any car owner who gets frequent messes in their car and also doesn't have enough time to clean it themselves, such as parents, pet owners, car rental companies, office workers, and more.

COBOR Concept and Pricing

Now that it's established who the people are that Cobor may benefit from, here is the concept of Cobor. As previously mentioned, Cobor is a self-aware vacuum much like a Roomba but far different at the same time. In terms of use, the owner places the 7 by 7-inch robot in the car, and the car should be cleaned by the time the owner comes back. The reason why it's different from a Roomba is that a Roomba is simply designed for the house environment, which is spacious and flat, as opposed to a car environment, which is complex and compact. This means that Roombas and other self-autonomous vacuums designed for houses will have a simple AI and won't be able to traverse through complex terrain such as car seats and floors.

On the topic of charging, the Cobor will have a charging station that should be compact enough, much like the vacuum itself. The charging station would be about 13 inches wide and 8.5 inches high, and it would operate much like current charging stations for robots such as I robots or shark matrix robots, yet this would be significantly smaller. It would also have to hold similar amounts of energy as compared to the other charging stations. This is done to make sure the Cobor has enough energy to clean up the whole mess and also hold enough energy to sustain its strong suction power, which is needed for embedded messes such as pet furs. There is a certain type of technology used in powerful vacuums called cyclone technology. Researcher Hee Soo Shin as well as other researchers conducted a study on tangential inlet twin flow (cyclone), and the results showed that it was more effective in engulfing embedded dirt than other vacuums, showing that cyclone technology is a great option to boost the power and cleaning capabilities of the Cobor (H.S., 2006). As of right now, there is good technology with lithium batteries, so the Cobor could be powered based on that. The reason why the charging station needs to be compact is so the car owner can simply take the Cobor either from the garage or even from the car itself to make it practical and lower the time that is spent by the owner getting the robot and putting it in the car. The charging station being in the garage is perfectly plausible, yet most questions arise about how it may be in the car. Such questions may be, "How will the charging station fit in the car, and where would it be?". As well as, "How would the charging station get power since there is no outlet in the car". The answer to the first question is that the size given for the charging station is enough for it to be in the trunk of the car, and maybe in the near future it could be compact enough to be under a seat, but with current technology, the trunk is a safe option. In terms of power, the Cobor charging station will be charged much like how wireless chargers and Airpod cases work(J.D, 2017), and then it will store the energy in a large battery for it to be placed in the car and charge the Cobor successfully for it to be able to sustain the Cobor wirelessly for a prolonged period of time, which is around a month. For a battery to be as powerful as the charging station, it can take inspiration from lithium car batteries. Although they are definitely not going to be as powerful as those used in cars, a fraction of the energy will be powerful enough for this task as well as a great option, considering that they are progressively evolving and have a much lower environmental impact as compared to other batteries (Scrosati, 2010). In conclusion, the charging station may utilize lithium-ion batteries to be powerful enough to power the Cobor even when not plugged into an outlet at the same time, so it could be in the garage or even the car trunk for long periods of time.

Two Different Models of COBOR

Now that charging has already been discussed, the next question is how the Cobor can traverse the car environment. Since a car's interior is very compact and complex, it will be very hard for the vacuum to navigate and clean it efficiently, especially taking into account that every car's environment is different. For it to be possible for the Cobor to vacuum it, the robot will need strong software as well as some form of transportation that can make it traverse through seats. To address the transportation problem, the researcher asked questions about two different types of vacuums for the same 15 subjects discussed before one that can clean flat surfaces within the car and one that can climb seats as well.

The first Cobor model can only clean flat surfaces, and the interviewees would be asked how much they would pay for it; this would be an indicator of how much people would pay for a more realistic and possible design for a self-autonomous vacuum. The Cobor will utilize modern-day technology, which is also present in other vacuums, but to adapt to the car environment and be able to take fur from the seats it will need strong suction power. Strong suction power can be sustained by the lithium battery discussed before, and the next obstacle left is how it will navigate through the curves of the seats. This could be done by adding a flexible bottom to the vacuum, presumably made of bristles or even a type of flexible rubber material. Essentially, how it would work is that the owner would keep their Cobor in the place that needs cleaning, such as the trunk or car seat, and it would be cleaned as long as there were no large dips, such as from the seat to the floor.

The second Cobor model has more capabilities that are terrain-based, and this would be more of a goal model which is harder to create than the previous. This is how it works: to adapt to the car terrain, the Cobor will need some sort of adhesion that could be utilized to climb both leather and fabric seats to efficiently clean them. Climbing leather and fabric surfaces be made possible through a certain type of adhesion created through biomimicry called gecko adhesion. Gecko adhesion has the properties of high capacity, reversibility, and dry adhesion, which allow it to attach and detach from large objects with ease. The reason why the biomimicry-based adhesion works so well for attaching and detaching is because it's modeled after the gecko. The geckos' feet are home to millions of minuscule hairs, which can be utilized as dry adhesion to any type of surface. To be specific, there are about 3 million of these hairs, each at around 14,000–2 mm, that are branched off into nanoscale spatulae. gecko dry adhesion is so strong that a tokay gecko could produce 10 N of adhesive force with approximately 100 mm2 of foot area. To traverse well with a strong adhesive force, geckos move their feet in a different direction, which deactivates the adhesion and allows them to walk normally. Scientists have made a type of dry adhesion inspired by geckos by using synthetic gecko foot fibers that have been created by nano molding using silicone, polyimide, polyvinyl siloxane, polyurethane, and carbon nanotubes (Bhowmick, 2015). Thanks to such a helpful innovation, the Cobor could be able to traverse through car interiors regardless of the material. This would be different from the previous model because now it could be placed on the floor and clean any floor due to its adhesion technology, and it could even clean the back sides of seats as well. Now that the models have been introduced, these were the results when asked about how much people would pay for both types of models.

Averages of Prices Offered for The Following Models (Found Through Interviews)

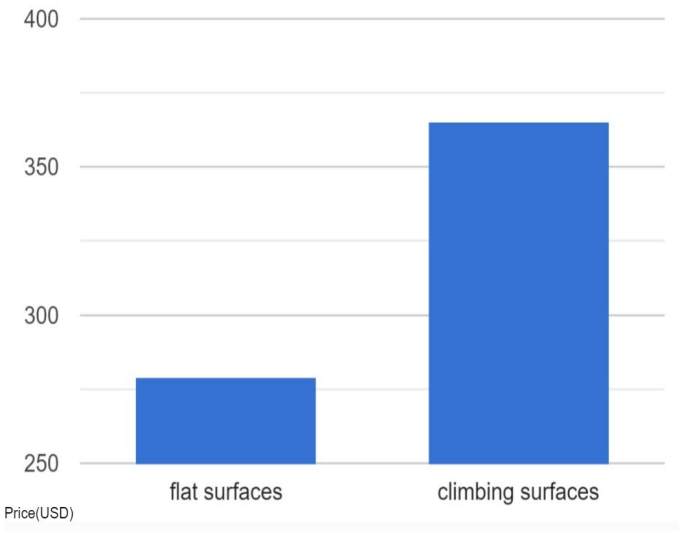

Figure 2. "Averages of Prices Offered for the Following Models": Price people would give for two different abilities: one that can only clean flat surfaces and one that can climb up seats and clean them too.
average for flat surfaces: 279.41
average for climbing too: 365.49

In the chart, there is a notable difference in the prices people would buy each Cobor model for. For the one that could only clean flat surfaces, people offered an average of 279.41 US dollars, while they would give 365 US dollars for the one that could climb surfaces, which is a staggering 100 dollar difference. Although it may seem as if everyone in the poll would pay more for the improved version, it is important to keep in mind that some only wanted the one that would clean flat surfaces because they mainly wanted just their carpets and trunks to be cleaned.

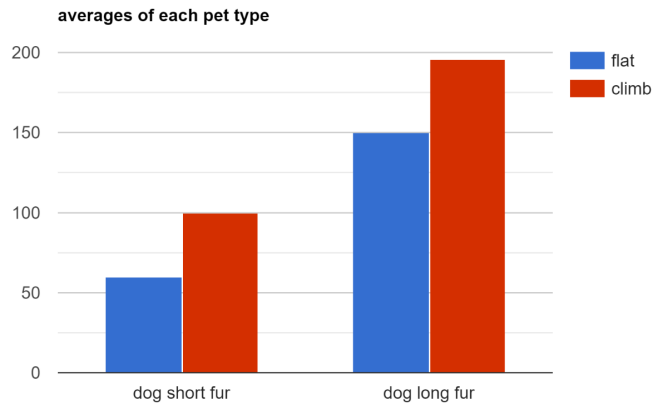

Figure 3, "averages of each pet type": Statistics of how much long-fur dog owners pay for each model of Cobor as opposed to owners of short-fur dogs The chart shows the price difference between those who have dogs with short fur and those who have long fur.

Taking everything into account, the best price for the Cobor model 1 (flat surfaces) will be 280, which is taken by the average, and the best price for the Cobor model 2 (climbing surfaces) will be 360, which is also an estimate of the average.

One final subject of the Cobor that is still not mentioned is the software. For it to be able to clean in the car environment, the Cobor will need good artificial intelligence that can make sense of its surroundings and avoid predicaments such as falling over. This can be done by adding sensors from the side and top to make sure to get a 360-degree view of the surroundings. Motion sensors for motion detection and ultrasonic sensors for calculating the distance between objects are just a few essential detection methods that self-assisted robots such as the Cobor need (M.S., 2020). It would then use pattern recognition to recognize obstacles such as walls or drops and avoid them. Something that can also be added in terms of software is an app. This app can be used by the owner to track where the robot is, visualize what mess has been cleaned up so far, and even give it instructions on what to clean so the robot can clean optimally according to the owner's needs. In the event of losing charge or certain predicaments, such as an external force damaging the robot, it will send a signal through the app, and the owner will be notified.

Conclusion

To sum it all up, messy cars are a big problem in modern-day society causing risks to many car owners, The existing options for car interior cleaning, such as car vacuuming and car detailing, are obsolete due to their wasting the time and money of the car owners. Most car owners want a presentable car that can stay clean, and these needs have been left unmet until now. The Cobor utilizing cyclone technology, biomimicry adhesion, and many other mechanizations can greatly benefit consumers and disrupt the car detailing industry, which is worth 36 billion US dollars, and not only that industry but the vacuum industry as well which is larger. The Cobor can benefit consumers in many ways that were not possible before, such as saving almost all their time by being entirely autonomous. Because it is able to clean the car frequently, its owners will be able to have a clean car that stays clean rather than getting dirty a week after the wash. Even if the car owner wants the entire car to be clean, instead of having to pay 100+ dollars for a professional to detail the car, the Cobor would already take care of the majority of the car, and all that is left is for the owner to just vacuum the corners they want, making the Cobor a great option for almost any car owner. Although the Cobor is not fully developed yet, it is certainly possible, and this innovation can get us one step closer to a vision where car owners wouldn’t have to participate in laborious cleaning and instead have the liberation to do what they are willing to do.

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