

Optimizing Food Delivery Efficiency: A Sensor-Based Robotics Approach to Minimize Spillage and Wastage

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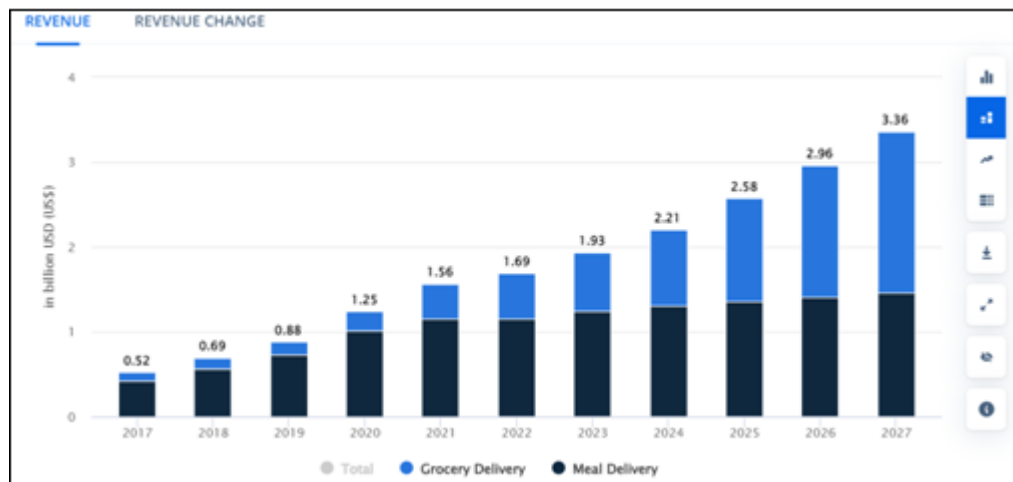
Abstract: In the last few years growth in the online food and delivery industry has grown exponentially, this increase in demand has brought a need for faster food delivery overall. Today it is estimated that around 15000 delivery drivers in Dubai are risking their lives on the roads every day, driving at dangerously high speeds to meet customer and corporation expectations. Due to the high speeds and sharp turns, the food being transported has a high chance of spilling creating huge financial set-backs for delivery workers. With the aim of solving this issue, we have created a prototype model utilizing fundamentals from the gyroscope. The model senses the motion of the bike through the GY-521 (MPU6050) gyro module and appropriately creates a counter pitch and roll movement in order to keep the edibles fully intact. The body of the prototype is 3d printed with appropriate dimensions, allowing for easier integration into already existing food delivery units. The various limitations for the prototype will likely find their own resolution when developing the final design. The model has great potential to be beneficial to not only delivery drivers but, for corporations and customers alike.

Keywords: Food Delivery, Robotics, Wastage

1. Introduction

The COVID 19 pandemic has caused unprecedented growth across the board when it comes to online food and delivery, this can be seen evidently in the UAE market with e-commerce transactions in the food and beverage industry seeing over 45% increase in the year of 2020 alone. As shown

in figure 1.1 the market size is predicted to further increase with a CAGR of 4.8 % during the forecast period of 2023 - 2028 projection values of USD from 12,465 million in 2022 to USD 15,757 million by 2028. Furthermore, the yearly revenue of the online food and delivery industry alone is projected to reach a further USD 1.93 billion in 2023 (Statista, n.d).



The surging boom in the industry has brought forth a variety of opportunities as well as constraints faced by influential corporations in the market. One such limitation is the possibility of food spillage during the delivery process.

2. Literature Survey

As part of the experiment and product design process we have decided to carry out research to understand the prevalence of the issue at hand, as well as evaluate other problem solving methods.

The experience of delivery drivers

It is estimated that there are around 15,000 delivery drivers on the roads of Dubai alone with the majority of these drivers

making their money on a per delivery basis rather than a fixed salary. Therefore, it is in the drivers best interests to make as many deliveries as possible which often results in driving at dangerously high speeds and taking much sharper twists and turns. In a survey conducted with delivery drivers in dubai, 20 out of 100 drivers openly stated that they did not drive safely. Due to this rash driving culture it is estimated that 21% of all food delivered has had some sort of spillage incident (CNA, N.D).

Food spillage is not only a problem for the customer but also for the delivery driver themselves. The official government documents regarding food delivery and transportation in the state "Foods shall not be delivered if the package is damaged or in a condition that is not acceptable to the consumer"

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(Dubai Municipality, 2022) suggesting that the responsibility of delivering the product in a pristine condition falls squarely on the delivery drivers shoulders. Though this is true to some extent, in most cases due to the time sensitive conditions these workers are under, this is simply not possible. As a result many food delivery drivers end up paying a refund, out of their own pocket, towards the damaged food, this is a large deduction from their already minimal income.

The financial struggle of the delivery drivers and the dissatisfaction from the customers can both be solved through fixing the overarching issue of food spillage and this is precisely what our product tackles. Through creating a mechanism that protects the food during the high speeds, we provide the drivers with assurance regarding the final quality of the food.

Government regulations

An analysis of government regulations have been performed in order to understand the problem better but as well as to aid in the process of developing a solution.

The Dubai municipality outlines a number of policies that must be followed in the design of food unit vehicles, majorly concerning the outer design. Official government documents state that food units in delivery bikes are to not exceed 50 centimeters in any dimension and, in addition, should also be made of a flexiglass, a versatile plastic material similar to glass but highly resistant to impact.

Furthermore, there have been new road regulations implemented in Abu Dhabi specifically targeting food delivery drivers. New regulations state delivery drivers are only permitted to drive in right lane roads in areas that exceed the speed limit of 100 km per hour. In a 5 lane road, this alters slightly to permitting the use of all 3 lanes to the right. The committee states that this is to help regulate traffic and maintain a high level of safety for all drivers.

Uber balance system

Created as a response to the increased food delivery orders during the COVID 19 pandemic, Korea based designers Min Ju Kim and Hyeonji Roh created a gyroscope - like mechanism that solves the problem of food spillage (Designboom, 2021). This design, adopted by Uber and fitted onto their delivery bikes, ensures that your package arrives at your doorstep completely intact, able to withstand sharp turns as well as high speeds taken by delivery drivers.



As can be observed in figures 2.2 the Uber balance system uses the principles of a gyroscope including 3 axis stabilizers. The mechanism ensures that the product is kept in a horizontal position and aims to minimize shaking, creating optimal conditions for food delivery.

Other methods of keeping food from spilling

Aside from primary mechanisms that keep the food intact there have also been precautions taken by drivers in order to reduce the amount of food spilled overall during transport. The following details a few such precautionary measures and as well as, evaluates their efficiency:

Making sure components are well sealed before transportation. Taking the additional time in ensuring that the packaging of the food is well sealed, especially if sauces or liquid beverages are involved, can be a deciding factor on if the contents will spill. This step takes a marginal amount of time however, and can be detrimental to the overall success of the delivery.

Using plastic film to wrap and secure items has been a simple yet effective way to ensure the content stays intact throughout the delivery process. This is especially effective with sealing the lids of liquids as they are more prone to spillage. This method may withstand moderate level speeds, nonetheless cannot provide full reliability when discussing higher speeds.



Quite often restaurants keep the food and drink in the same bag, separating the two can be effective at keeping the food from contamination in the event of the liquid spilling. This step is fundamental however, does include any precautionary measures against the liquid itself spilling.

Segregating items that are different in temperatures: With the best interests of both the customer and the driver in mind, the

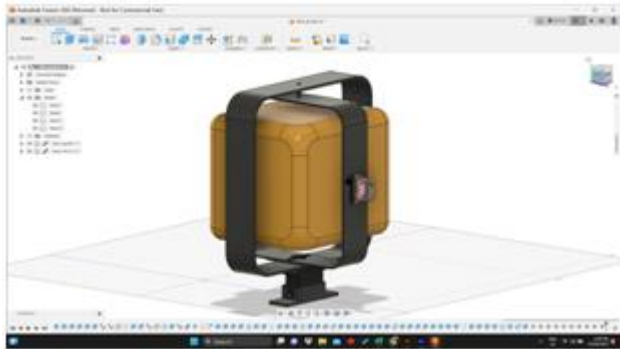
Dubai municipality outlines that food items of different temperature are to be kept separate from each other and with proper insulation in order to preserve the best condition of the food.

Our solution

Our solution also adopts principles from the gyroscope, similar to the uber balance system. However, rather than creating an entire structure to be fitted on the back of delivery bikes, we have opted for a mechanism that can be placed into the delivery carrier itself. Doing so allows us to be more economical when considering applying the design in a real life context as, using our design allows for efficient and simple integration rather than companies having to replace the whole delivery basket. Choosing our option due to its simplicity when considering integration provides huge financial benefits to our target audience, the delivery corporations in the UAE, ultimately making our product the most favorable.

Product design and mechanism

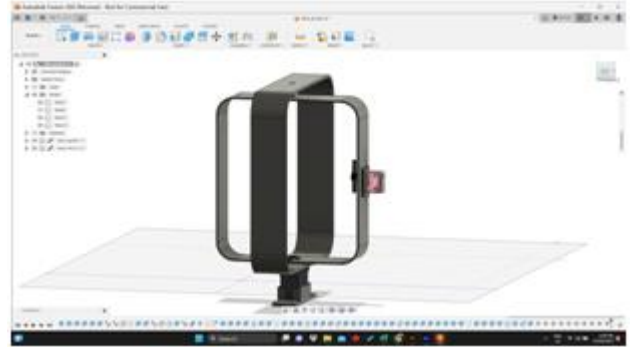
The project consists of two servo motors, one standard servo motor (HiTech HS-322 HD) and one micro-servo motor (SG-90). These servos are the most integral part of our design as they are what create the pitch and roll movement based on the motion of the delivery bike. This counter pitch and roll movement is what ensures that the food stays intact during the delivery.



Controlling the movement of these servos is an Arduino UNO microcontroller. The Arduino works in collaboration with the GY-521 (MPU6050) gyro module which is the component responsible for detecting and communicating the movement of the bike. The Gyro itself is controlled using the Arduino library "MPU6050_light" through the 12C communication protocol. The 12C is an inter-integrated controller intended for short distance communication between multiple digitally integrated circuits. In order to obtain information regarding movement, the gyro mainly relies on the X and Y rotational values that are mapped into the respective servos angle control.

For the X axis, the angle between -80 and 80 is mapped to 25 and 180 degrees respectively of the servo angle. Similarly for the Y axis, angles between -60 and 60 are mapped to the 8 and 128 degrees of the servo. The range of the angles may vary depending upon the position of the parts fixed in the initial

stage; however, when looking at the overall mechanism the percentage of error this variable contributes is quite insignificant.



The entire body of the model is 3d printed to fit the dimensions of a standard food delivery unit on a delivery bike. The CAD files of the design are attached in figures 3.2 and 3.3.





3. Limitations

Considering and evaluating limitations of our own design provides a better insight into the possible real life applications. Considering this is a prototype model, reviewing the limitations opens up the opportunity to make a better and improved final product.

The micro - servo motors used in the prototype are not able to withstand high load application at the current moment, however this proved no issues during the testing process other than minor jitters. This is an isolated problem rather than a fundamental one with the design as the solution simply lies in using durable motors when creating the final product.

The gyro sensor has a high likelihood of adding errors and though this could be due to various factors, it is mainly due to external interference of the gyro module. Ultimately, this requires the reset of the entire gyro module in order to re-calibrate. Though no exact solution has been proposed for this specific issue, it does not pose a major threat to the overall function of the design.

As can be observed any of the limitations of the design arise due to its characteristic of being a prototype. During the testing process it was evident that speed of rotation around the X and Y axis has to be slow or medium level. This is a setback as at the present moment in time the product will not be able to withstand high speeds and sharp turns however, with the addition of future modifications the mechanism has high rates of success.

Equipment list	
Component image	Component name
	Arduino UNO microcontroller
	GY-521 (MPU6050) gyro module
	Micro servo motor
	Standard servo motor

4. Results and Discussion

The online delivery industry has been ever growing not just in the UAE but throughout the world and, through a process of researching, developing, analyzing and evaluating we have created a product that can likely provide an array of benefits to the delivery corporations and drivers alike. Using a mechanism such as ours allows delivery drivers to feel assured and would greatly benefit in enhancing the impact of the food delivery guidelines outlined by the Dubai municipality. Our device projects results of excellence far better than existing methods to secure food. Moreover, the design of the model is easy to integrate into already existing food units on delivery bikes meaning companies are not required to make a significant financial investment towards application of the new technology. This, combined with higher rates of customer satisfaction, is a sizable opportunity for corporations looking to establish a solid customer base.

Although at the present moment the prototype has various limitations that may impact its overall functionality, there are no issues with the fundamentals of the design. Furthermore, the majority of the setbacks discussed prior are likely to resolve in the process of creating the final product. Through the testing process the mechanism proved to have promising potential, creating true impact in the delivery industry.

5. Future Scope

We believe that this project has a major potential in the booming industry of online food delivery, especially in the UAE. The mechanism is overall easy to interact with and apply it into already existing delivery food units, giving it a huge financial edge. Although the prototype of the product has limitations that hinder its performance, the fundamentals and integrity of the mechanism is unaffected.

We strongly encourage both delivery corporations and the UAE government to consider the application of this mechanism into their systems. The implementation of our product can not only result in a better online food delivery experience for the customer but, also would contribute in improving the situations of delivery workers across the country.

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