Autonomous Ice Cream Vending Machine for Colleges and Cities

-Nathan Nohr 9/5/2022

High traffic vending machines are reported making more than $400 in sales each month, some reported as high as $2,800.[1] There is no place with more traffic than sidewalks. An autonomous ice cream vending machine could intelligently navigate campuses and cities to provide convenient frozen treats. The idea is to combine the fun and nostalgia of an ice cream truck selling cold ice cream on a hot day with the autonomy and convenience of a traveling vending machine.

[1] https://thehustle.co/we-interviewed-20-vending-machine-owners-heres-how-much-they-make/

Details

A 50W solar umbrella would provide shade and renewable power to the coolest robot on the sidewalk. Four large wheels would provide a stable way to move from corner to corner. A network of cameras and ultrasonic sensors will prevent collisions. GPS, map data and cameras will provide data to guide the robot. Customers will be attracted by ice cream music and bright colors to use a touch screen interface and verifone payment method. A gravity fed dispenser will provide customers with their selected pre-packaged frozen treat.

Schedule

9/5	**Preliminary** Write proposal, obtained approval from Ann Arbor attorney about autonomous robot on sidewalk. Reached out to Paypal Zettle and Verfone sales about buying card reading hardware.
9/8-9/20	**Planning** Delegate the following tasks and setup plans to discuss important elements. Develop a preliminary bill of materials for main elements. Using the selected parts create a functional block diagram to get an idea of power requirements. Create a 3d layout plan for how everything will fit together. Determine how to modify a freezer to operate as a gravity fed frozen treat storage. Finalize LLC business registration, re-verify legality of autonomous robots on sidewalks with both city and college. Determine cellular data plan to use for payment verification. Order devkit for board. Determine torque needs for motors.
9/21-10/4	**Setup** Re-group to discuss possible problems and edit BOM. Then order all parts for the prototype. Discuss sensor integration coding methods. Decide how to abstract and coding tasks of data collection, purchasing, computer vision, safety, motor and dispensing control. Determine hardware integration connection including power, cellular data, and card verification. Focus on safety, ease of testing, and durability.

	Finish formal proposal. Verify inventory and begin ordering parts. Begin CAD for 3d printed parts.
10/05-10/23	**Construction and testing** Order parts by 10/09. Finish PCB design and order the boards. 3d print cad designs, and assemble the physical frame. build sidewalk path planning viewer. test out computer vision algorithm and logic. Implement state machines for selling to traveling. Download sidewalk map data for use in travel planning. Test safety shut offs. Work on sensor integration, camera feed, calibrate distance sensors, gps data. impliment interfaces for each.
10/24-11/8	**Application testing** add motors, wheels, battery, MCU, and solar panels to frame. Test robot movement to basic commands on sidewalk. Modify the freezer and add the gravity dispenser. Verify payment verification. Test Computer vision for recognizing people. test ultrasonic distance motor stop.
11/9-11/22	**Debug** Test autonomous driving on sidewalk clear of obstacles. Impliment more specific classes in computer vision recognition including obstacles and roads. Test selling process on touch screen. Fully assemble robot. Integrate all system sensors. Do a full test transaction. Test stability on cracks/ off sidewalk. Test it in difficult intersections. test with bikers and skateboards going by. Test on sidewalk with obstacles.
11/23-12/8	**Real world Release** implement a web page or app to see where the bot is, check inventory and summon it. fully stock and start making money.
12/9-12/11	Finish final report

Budget

Part	Quantity	Cost per	Cost total
RPI	1	45(free/already have)	0
Processor	1	20?	20
Paypal Zettle	1	100	100
Freezer 3CU	1	150	150
Flat free tires 4x	1	50	50
Motors	2	50	100
Solar 1$/watt	100	1	100
Camera adafruit 613	2	60	120

ultrasonic sensor	4	12	48
power electronics	1	20	20
touch screen	1	50	50
Build materials	1	100	100
stepper motors	3	20	60
electronic passives	1	82	82
Total			1000
PCB printing			
Business license	1	50	
Speakers	1	5	
Lights	10	5	
Battery 60v 1ah	1	60	
Cellular module+data plan	120+plan	150	
Shipping	50?		

Issues

1. Budget.
    a. This project could easily go over budget. Likely a lite version of this idea would be passable. In the budget many items I took an average when cheaper alternatives may be available like wheels cameras and touch screen could all be greater than 50 percent cheaper saving 120 dollars. Registering as a business should be considered a stretch goal if we have the money to do that. Additionally, since there are so many different elements and parts of this project a 6th member could be included to make the budget higher and workload per person easier. A distinct assignment of tasks might help this exception be acceptable. A discussion with the instructor about what features may not be necessary would be beneficial.

    b. A likely solution would be to break the project into two separate projects.

    1. A freezer vending machine solution that fits on a portable chassis. This is a new project because existing freezer vending machines are large, very heavy, and require a wall outlet. The list of electronics used would include: MCU,

capacitive touch display, cellular transceiver, payment verifier, stepper motors, motor controllers, power electronics for high voltage and low voltage bias supply. As part of this project a web page or app would be set up to receive smart inventory tracking from the vending machine. Since this is smaller than traditional glass covered vending machines, extra design emphasis would be put on maximizing the number of products that can fit and be dispensed. Rather than modifying an existing freezer solution a reach goal would be to make one.

2. An autonomous sidewalk robot. This bot would use computer vision to navigate sidewalks and recognize and count pedestrians as well as other sidewalk obstacles. It could safely move around with people. It would serve business by either providing a chassis for mobile vending or It could collect data to develop autonomous delivery solutions and determine ideal spots for business. Ideally it would be able to carry over 100 lbs and have at least 2 cameras to gauge distances and increase the bots FOV. The list of parts includes: motors, motor controllers, 2-4 quality cameras , 4-8 ultrasonic sensors, MCU, terabytes of memory battery, solar panels. The significant challenges of this project would be safety, computer vision and autonomous driving.

2. Business license / autonomous driving laws

I already reached out to the city of Ann Arbor attorney and was informed that there are currently no city or state laws regulating this. I was given an additional contact to reach out to in regards to pending legislature. I did research as to licensing for sidewalk vending and we would need a LLC and a certain food license for selling frozen food.

3. Safety and testing.

To be certain this was safe to operate unsupervised an amount of testing not possible in a semester would have to be completed. As is it can be brought to work in most standard sidewalk situations while supervised. I think the best solution to guarantee safety would be a mechanical safety tether and shutoff button. So if the robot started to run away or act buggy a pull of the tether would break the power circuit and shut off the bot. Additionally a power button would provide easy access to shut off as well while testing. The bot would be supervised at all times with these methods.

Stretch Goal

Implement a website to track inventory and location remotely. Could transform to make a customer interface. see where the bot is, request it, leave reviews. Registering as business could be moved to a stretch goal as its non-critical to the technical aspect of the class and would save money

Success will be measured by completing a working vending machine that can travel supervised around the diag stopping to avoid collisions and complete transactions for frozen goods while under its own solar power.

Electronic Braking System for Longboards

-Nathan Nohr 9/5/2022

As of 2020 the long board and cruiser board market size was $800 Million. Of the skateboard types long boarding is the fastest growing, “expanding at a CAGR of 3.8% from 2019 to 2025”[5]. This is a significant market that lacks an important safety feature: brakes. There are four methods of slowing down. The easiest is to ride a hill out until the friction of the road and bearings stop you, however in many cases riders need to stop on demand to avoid collisions or high speed instability. Traditionally, skateboarders use footbraking, where the rider balances on their front foot at high speeds and drags the heel of their rear foot on the ground burning through the sole of expensive skate shoes. Alternatively, there are more skilled riders that learn to drift to stop, this requires wheels designed to drift and significant skill. Riders who slide stop wear extra protective gear since a bad slide at 20-60+ mph can result in serious injury or death. The last ditch effort many new riders use to stop is to jump off of the skateboard. Bailing the board often results in falling on concrete and allows a high speed board to cause damage to cars or hit other pedestrians. There are very few existing brake solutions on the current market. However skaters on online forums have expressed interest [4]. A brief poll from the michigan skate club shows that 22% of the 17 people surveyed would pay for an electronic braking system for their longboard. Existing brake solutions are mechanical in nature and cost between $65 and $225. They require significant modifications to the trucks or board to allow for a pedal to apply pressure[1,2,3].

[1] https://www.amazon.com/Longboard-Brake-Mount-Single-Rubber/dp/B01I4WWBFM
[2] https://www.thisiswhyimbroke.com/longboard-skateboard-brakes/
[3] http://pennybrake.com/product/cruiser-board-brake-to-us-uk-eu-asia-etc/109/?cate_no=1&display_group=3
[4]https://www.reddit.com/r/ElectricSkateboarding/comments/l7bxrk/manual_board_electric_brakes/
[5]https://www.grandviewresearch.com/industry-analysis/skateboard-market#:~:text=Long%20board%20is%20the%20fastest,3.8%25%20from%202019%20to%202025.

Description

The idea is to build an electronic braking system that users control with a wireless remote to apply brake pressure via a replaceable brake plate. An advanced version of the braking system would use a camera and custom wheels that have markings on them to allow the mcu on the braking system to calculate the wheel speed to regulate the max speed of the board. This would help new riders to safely learn how to longboard and aid pedestrians who use longboarding to travel the city. Electronic brakes significantly increases the safety of longboarding and It also enables long boarders to travel on more roads as steep hills are impassable for people who haven’t learned to footbrake or slide stop.

Parts list:

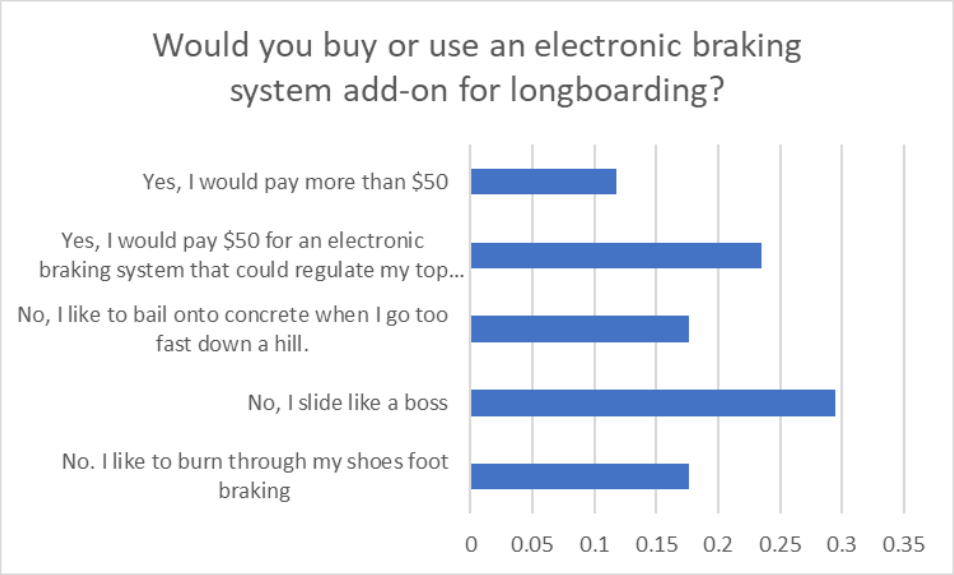
Braking system: MCU, precise motor for applying brake pressure, camera to judge wheel speed, light to illuminate wheel at night, bluetooth antenna to communicate with remote, LION battery and bms system.

Remote control: MCU, Trigger motor to measure desired brake pressure, bluetooth antenna, solar charger, display lights, LION battery.

Optional improvements: solar charging board attachment for brake module.

These parts would be well under $500. I have access to 3d printers to prototype housing and parts as well as three different sizes and styles of boards to test the robustness of. This project presents a signal processing aspect of calculating board speed from wheel rotations, a wireless aspect with bluetooth communication, user experience aspect with clearly defined customer needs, and a renewable aspect as all of this can be solar powered for ease of ease of use, sustainability, and waterproofing.

Poll taken by University of Michigan Skate Club members 17 response, more pending



*Percent of skaters that agree. One response per respondee.

Success would be measured by a braking system that can bring a board with 70mm wheels and new zealous brand bearings to stop from starting standstill at Madison and S State street down the hill to Madison and S Division street stopping before the stop sign and free riding for at least 70% of the hill. This is an easily achievable task with footbraking.