BACvision®: a Revolutionary Device for Safer Roads

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Executive Summary

With the number of licensed drivers in the United States reaching unprecedented levels, the risk of driving under the influence has never been greater. Increased accessibility to automobiles has allowed for a new generation to control vehicles: 4,000 pounds of steel that could ravage lives in an instant. When combined with intoxicants, automobile operations yield a deadly result reflected in the 10,874 fatalities from drunk driving in 2017—a death every 48 minutes[1]. Currently, breathalyzers are the sole blood alcohol content (BAC) detection system in the automotive safety industry. Not only are they inaccurate, with error rates of up to 26%, but they also lack the capacity to detect intoxication by narcotics[2].

Our team is an entrepreneurial startup with a vision to create a revolutionary device for motor vehicle safety—BACvision. Our product will serve as a stand-alone apparatus that can be implemented by law enforcement agencies and individual motor vehicles to accurately detect blood alcohol content (BAC) and quantify the presence of other intoxicants with the revolutionary use of ocular metrics. Our goal is to create a safer tomorrow for all drivers.

1. Customer Profile

BACvision is directed towards two target audiences. The first is car manufacturers, which provide indirect access to civilian drivers. A record-breaking 222 million licensed drivers in America were reported in 2016, with American sales that year topping 17.6 million cars and trucks[3][4]. Based on production statistics from domestic car manufacturers, we estimate BACvision to be integrated into 5% - 10% of total cars produced over the next 3-5 years. However, this is a conservative estimate, given that worldwide car manufacturing is a booming industry, with over 88.1 million automobiles sold in 2017 and on an upwards trend[5]. Our percentage range indicates that we should be able to equip as many as 1.7 million cars with BACvision upon maximization of our market ceiling.

The second primary market is law enforcement agencies. In 2012, the United States Department of Justice estimated that there were over 750,000 sworn officers in America. More than 12,000 local police departments were operating in 2016, and BACvision is expected to reach many of these agencies due to its easy-to-implement, modular design[6]. We project that approximately 500,000 licensing copies of BACvision will be sold at our product's greatest market capacity. Two in every three police officers are typically equipped with DUI detection systems, thus a complete overhaul of the existing system would be the ultimate objective for BACvision, given both its price viability and accuracy.

2. The Problem

According to the National Highway Traffic Safety Administration (NHTSA), in 2017, 15% of drivers involved in fatal crashes during the week were drunk, rising to 28% on weekends[1]. While recent DUI mandates have marginally improved the security of vehicular transportation, they have increased the time required of law enforcement officers to conduct holistic BAC analyses and raised associated capital expenditures.

Current breathalyzer apparatuses cost upwards of $120 per device and have inaccuracies of 10-26%[2]. According to a recent study conducted by the NHTSA,

approximately 23% of all drivers charged for DUI may be victims of inaccurate breathalyzer results. For blood-based BAC tests, lack of sterilization, coagulation, vial mix-ups, and fermentation of blood are all factors that drastically diminish the precision of DUI detection. With respect to urine assessments, ethyl glucuronide, the alcohol metabolite whose quantity is typically analyzed during road tests, can remain in an individual's system for up to 80 hours, serving as an antiquated representation of an individual's BAC[7]. Current field sobriety tests have inaccuracies of 23% and typically take 20 or more minutes to complete. Furthermore, swab test kits that are used for on-site drug analysis are costly and involves unnecessary officer exposure, which may be further complicated by lack of cooperation from the driver.

Another inadequacy of current breathalyzer systems is their inability to quantify the presence of narcotics. Among the 37,461 individuals killed by driving accidents in 2016, 43.6% of drivers were found to have positive drug test results. Almost 7% of drivers, most under the age of 35, who were involved in fatal traffic crashes tested positive for THC, the principle ingredient in marijuana[1]. Despite this, law enforcement agencies still lack an effective means to detect narcotics-related DUI. As a result, law enforcement agencies are often unable to properly and safely identify drivers under the influence of illicit substances, posing a legitimate threat to the welfare of society.

3. The Solution

BACvision employs MATLAB and Simulink artificial intelligence algorithms for a comprehensive substance impairment measurement device. As our product relies on high-precision optics, it is less invasive and more time-efficient. Additionally, we employ four indicators: pupillary light reflex, eye redness, gaze-evoked nystagmus, and pupil dilation. These indicators have all been highly correlated with effects of alcohol and drug intoxication. Binocular measurements are based on a dual-camera system, with multi-chromatic stimulation (white, green, blue, and red) to generate more precise pupil reactivity measurements.

a. Ocular Metrics
    i. Pupillary light reflex
        1. Quantified by BACvision algorithms to measure changes in reactivity
    ii. Eye redness: Images taken in rapid succession → input → matrices → pass through a neural network → detect deviations from expected measurements
    iii. Gaze-evoked nystagmus: Eye tracking source code
    iv. Pupil dilation: CV architectures to assess the major and minor axes of pupil
b. MATLAB
    i. Digitalization of pixelated pupil scan
    ii. Binarization of values → Hough transform algorithm
        1. Initial boolean output of BAC → Correlation of pupil dilation to specific BAC measurement
        2. True/False return for narcotic presence

c. Individual Drivers
    i. Ignition interlock: Two-step testing system
        1. Driver fails on first try → thirty seconds delay and re-test
        2. Driver fails second reading → car engine locks and emergency contact is alerted
d. Law Enforcement Officers
    i. Application software installed on phones
    ii. 20-second pupil assessment period → BAC measurement and narcotic presence

4. Unique Value Proposition

Our product is unique due to its capacity to be implemented for law enforcement usage with its modular design, or integrated directly into a car dashboard for individual use. The aforementioned measurements are taken together to determine whether a driver is inebriated. This entire process is performed instantaneously when a driver is pulled over (BACvision for police), or when a person enters the driver seat (BACvision for consumers) with little need for human intervention, drastically reducing error and police subjectivity. Applying a unique weighting heuristic based on optic measurements of the major and minor axes of a dilated pupil allows us to create our own algorithm for BACvision, thus providing a proprietary advantage over emerging competitors. Moreover, with the modularity of BACvision as a mere software for the phones of law enforcement officers, our product effectively diminishes the risks associated with a physical system overhaul.

a. Accuracy
    i. Common breathalyzers such as BACtrack, which utilize Breath Alcohol Content (BrAC) to estimate BAC are inaccurate because of varying partition ratios, radio frequency interference (RFI), mouth alcohol, tainted breath samples, and numerous other sources of error that lead to a false positive rate of nearly 1 in 4 subjects[2][8]. BACvision eliminates these by utilizing ocular metrics that correlate with BAC, allowing for a mere 1% source of error.
b. Safety
    i. Police currently use chemical field tests for narcotics testing which pose a threat to officer safety. In an article by The Denver Post, they state that due to field testing hazards, "...dozens of officers have become ill, including 18 in one raid last year in Pittsburgh."[9]
    ii. BACvision is noninvasive, as it utilizes images taken in rapid succession to track various ocular metrics, ensuring efficiency and minimal discomfort for civilians and police. Furthermore, though we are currently focused on marijuana abuse detection, with further research, we seek to expand BACvision's algorithms to assess the presence of an increased range of narcotics. Moreover, we are looking into the application of a dashboard pupil scanner as a driving-fatigue alert mechanism, thus encompassing three of the most significant reasons for driving accidents and fatalities.

5. Revenue Model

a. Primary Revenue Streams
    i. Our primary revenue stream is comprised of two parts. The first major source is expected to come from the sale of our ignition interlock dashboard camera to car manufacturers. We plan on starting with American car companies, including Ford and General Motors, to avoid international legal affairs. The second point of profit will be in licensing agreements to local law enforcement agencies. These agreements would renew on an annual basis, thus generating a sustainable source of revenue for future company expansion and product research and development.

b. Unit Variable Costs
    i. Currently, the product costs upwards of $30, consisting of product licensing fees through MATLAB and usage of GPU host servers for rapid data processing. However, our software code is only at 73.5% of its maximum efficiency. With more refinement and further scaling of our product, the cost of production and implementation will decrease significantly, even as its functionality increases. We hope to achieve a maximum optimization of 98% - 99%. Such developments will be enhanced by greater product efficiency and economic scaling. Therefore, we hope BACvision will eventually achieve an overhaul of the DUI detection market.

c. Product Selling Price and Unit Profit Margin
    i. BACvision will retail at $70 per software copy. We selected this price given the established nature of breathalyzers within law enforcement agencies and the absence of ignition interlock systems in produced cars. Not only does this price level represent a 40% price reduction as compared to the $120 breathalyzers used by law enforcement officers, but it also denotes a mere .14% price increase from the cost of an average car. Coupled with our initial profit margin of 57.1%, which will eventually rise to over 300% through product refinement, BACvision has the potential to ameliorate DUI-related fatalities and generate a sustainable source of profit.

d. Development Cost
    i. The BACvision team is currently in the process of filing for a provisional patent based on the technology that we use to correlate pupil dilation with blood alcohol content and the presence of narcotics, whose filing fees range from $70-$280. We will eventually file for a utility patent, in which case we will use services such as Rocket Lawyer to minimize the costs typically associated with hiring a patent lawyer. The cost of prototyping will mostly be offset by the use of our school's Optics Lab and Electronics Lab.

e. Operating Cost
    i. $50 for an Individual MATLAB Student License (1-year subscription)
    ii. $0.20 per hour for a NVIDIA GRID GPU License

6. Meet the Team

The Autovision Technologies team consists of two core members: juniors Philip Pan and Mia Yang. Both share similar interests in biology, computer science, and entrepreneurship, enabling us to evenly divide work with respect to product research and market analysis. In the past, we have collaborated on biomedical research projects ranging from the purification of water to the effects of ethanol on the behavior of Drosophila Melanogaster. Philip is vice president of his school chapter and Mia is a regional director for LaunchX Clubs, an organization that promotes high school entrepreneurship. Furthermore, Philip has started his own company in the past, CrossCheck, which also applied artificial intelligence algorithms to airport security processes. This company allowed him to attend the CONRAD Spirit of Innovation Challenge National Finalist Summit in 2018. Mia has also pursued extensive research in ophthalmology, shadowing a trained ophthalmologist over the summer of 2018. Given our experiences together and our combined passion for entrepreneurship, we decided to explore innovations in technology that would ameliorate prominent societal hazards.

7. References

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