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ECE 445

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New Generation Addiction Control and Recovery Device System with Absolute Safety and Privacy - working with the Drug Addiction Research Team

1. Problem:   
   “First you take a drink, then the drink takes a drink, then the drink takes you.” – F. Scott Fitzgerald. As Fitzgerald says, unconscious Addiction is becoming a more and more common problem in modern society. By “unconscious,” I mean habits that sneak in slowly, built by small daily choices and cues, so people don’t notice the slide until it is strong. There’s many materials that can cause addiction in individuals' lives. Here I include both substances and behaviors. Some are relatively not impactful, like addiction to high sodium concentration, addiction to certain neuron impulses like music, even addiction to alcohol for most of the cases. I don’t mean these are harmless; only that for many people the day-to-day harm can be lower. Alcohol addiction can also be severe; I’m talking about mild use here. But some are much more horrifying, like addiction to smoking (more specifically nicotine), addiction to fentanyl, and addiction to cocaine. These often pull people in fast, with strong cravings, risky choices, and higher risk of death. All those substances deal a considerable amount of damage to the health of the addict and more or less influence the people around the user. Think heart and lung problems, changes in mood and thinking, money stress, and family strain.  
   But this should not end here. Naming the harm is not enough; we need a clear plan to stop the slide. “It does not matter how slowly you go as long as you do not stop.” – Confucius. Like Confucius said, if there is no stop to the addiction then the addiction will eventually roll down the hill like a rock no matter faster or slower, a brake is needed for this process. The point is that steady effort matters more than speed, but pushes from stress and daily life keep the rock moving.  
   Do we have a stop method for addiction? Certainly yes, there are many addictions known to be reversible and even the ones that are non-reversible, the symptom of the addiction can be controlled to be at least less severe. But there exists problems with the current method. Two big gaps stand out significantly in real life. The base logic for the addiction recovery is usually step-by-step. The steps are often fixed by a plan, not by how the person feels that day. Usually the addict needs to control the addiction level from severe step by step to nearly no impact, but if the process is too quick then the result can also be bad. It works like trying to reshape a Bouncy Ball, if we try to push too hard it will make a huge bounce back and eliminate most of the distance that has already gone through, in the worst case the addict might even be worse from the start because of the bounce. When that happens, the person loses trust and energy. They may even smoke more to calm the crash.  
   All the current methods rely heavily on the self-regulation ability of the addict: the addict has to lower the addiction level step by step with a highly organized daily routine. This assumes strong willpower every hour, which is not realistic for most people. Life is messy, work shifts, kids, money, and stress can break the routine. This sometimes works well but in most cases the result isn’t optimal enough. There are mainly two problems: First, the self regulation ability of the addict is usually not well enough. Willpower rises and falls during the day, but cravings and desire don’t wait. Sure there exist addicts that have a strong will to make a recovery from the addiction for reasons, but in most cases the addict only knows the current addiction phase is not healthy and have a relatively weak will for making a recovery, which in this case the addict may give up the process when feeling horrible. This drop-off point is the key failure we must design for. Second, the self control model is not optimal and scientific enough most of the time. Most plans don’t measure anything in real time. Even if the addict tries one’s best to regulate oneself, due to the fact that the human body is a huge chaotic system, there is no way that the addict will have a perfect endoscopic view to know what should be the correct dose for that specific moment. Nicotine fades fast, so strong desire can spike many times a day. People end up guessing dose and timing, which causes under-dosing (white-knuckle cravings) or over-dosing (nausea, dizziness).  
   So what we are aiming for then, is to work out an optimal systemic solution for the addiction recovery for smoking (nicotine) addiction. In simple words, a system that senses, decides, and helps right when the urge hits. It should be easy to use, low cost, and private. We aim to solve the problem of smokers not being able to self-control accurately and regulate enough in a precise scientific responsive system. Today’s tools are one-size-fits-all, slow to react, and too hard to follow under stress. We need a responsive loop: notice the trigger, then give the right aid, and then check the effect, then adjust and do it again in time.
2. Team Members: Adrian Santosh, Bernard Richawn, Yixuan Li
3. Solution: We need a solution that at least is able to perform four functions.   
   First, the system should be able to detect the heart rate and

Second, the system should have the ability to analyze the data input, then produce the best optimal solution for the current status.   
Third, the system should have the ability to control the release of the material for drug addiction recovery.   
Fourth, most importantly the system should be able to provide multiple level security checks to make sure even in the worst case the system should not produce any risk.

1. Solution Components
   1. Privacy: We do not plan to connect any external linkage into the system so the user’s privacy should not be exposed to any external source. Also, we do not plan to use any long-term storage so even if the system is hacked it should not provide any readable information. If it is possible we will also add some encryption method for the data and hardware/software self-destruction function if the system is forced open in an unwanted way. The user's privacy is crucial and we want to protect it as much as we can.  
      Possible Device: Fingerprint Scanner: GT-511C3 (x2, White cabinet/organizer); SD Card Breakout: BOB-12941 (x1, White cabinet/organizer)
   2. Sensor System: The sensor should be set in a non-invasive way and since we do not plan to connect the system into any external linkage.
      1. First Sensor System: This sensor system should be set for testing the fluid in the Oral Cavity Region. For example Salavia. The sensor should be able to detect at least the existing nicotine concentration in the mouth region.
      2. Second Sensor System: This sensor system should serve as a backup for the First Sensor System, detecting the existing nicotine portion in the exhaled air.  
         Possible Device: Pulse Sensor: Adafruit 1093 (x4, White cabinet/organizer)
      3. Safety Measuring System:
         1. Emergency detecting warning: Watch states like blood pressure, heart rate, symptoms, and dose history. If any sign crosses a safe line, it blocks dosing and shows a clear message. Directly alarm the user for unusual cases.
         2. Sensors adjusting and comparing: This part might have to work with the microcontroller. It should compare the two data received from the sensors and if one of them goes totally insane then it should attempt to follow the one in the normal range. And if both sensors totally lose control, it will then use the user-input and default data as signals to send to the Microcontroller Units. Warnings should be sent to warn the user about the abnormality of the device sensor part.
   3. Backup user-input port: The user will have a way for using the user control port to provide supplement information for the treatment plan. In the worst case the user can solely use the subjective control input to control the device when all the sensors are not working. Simple slider for urge (1–10, just for a reference for the treatment). Another functionality is in the worst case when all the sensors fail, the port can be solely used for the next dose of treatment while still having a solid respect in the treatment limit.   
      Possible Device: Keypad: 96BB-006-R (x3, White cabinet)
   4. Microcontroller Unit
      1. Ports: Safe power port and covered plugs for sensors/maintenance. Marked shapes so parts can’t be plugged in the wrong way. There also should be Water-resistant covers considering the use of liquid frequently happens.
      2. Microprocessor: Include a timing system. Do most of the logic operations, when the signal is sent from the Sensor System, it should perform a logic and then give the suggested dose to the output system.  
         Device: STM32 Device as for right now.
      3. Safety Check Software System Part: This part should be implemented in the Software, when the dose is significantly wrong compared to the previous data, the system should produce a warning and use a different one than the mistaken suggestion.
      4. Safety Check Hardware System Part: There should be a chip that guards the output message in case the software is failing. Irregular commands should be switched and failing commands should shut down the whole system and inform the user the device is failing.
   5. Three tanks overview system:
      1. Nicotine Tank:
         1. Volume: Need to decide a specific volume for the Nicotine Tank so the design has sufficient space but also not far wasting the design requirement.
         2. Storage Material: We have to decide what kind of material we need to use for the tank, to best prevent the corrosion and erosion from the liquid.
         3. Temperature detection: ideally we should also have a temperature detection to make sure that the liquid has the correct state and ensure the safety at least on the side of temperature. There should be a warning sent to the MicroController in case the temperature is over the safety line.  
            Possible Device: Liquid Temp Sensor: Digi-Key 480-2016-ND (x2, White cabinet/organizer)
         4. Leaking Detection: There should be a detection device for the tank in case it is leaking.   
            Possible Device: Load Sensor: SparkFun SEN-10245
         5. Leaking Management: At least there should be two layers of walls for the container to make sure that the leakage will not harm the rest of the device. Also serves the functionality of blocking the leakage from the external world.
         6. Safety Detection: If an unreasonable command is sent, safety measures should be enforced.
      2. Liquid Vapor Pod:
         1. Volume: Need to decide a specific volume for the Pod so the design has sufficient space but also not far wasting the design requirement.
         2. Storage Material: We have to decide what kind of material we need to use for the pod, to best prevent the corrosion and erosion from the liquid vapor.
         3. Leaking Detection: There should be a detection device for the tank in case it is leaking.   
            Possible Device: Load Sensor: SparkFun SEN-10245
         4. Leaking Management: At least there should be two layers of walls for the container to make sure that the leakage will not harm the rest of the device. Also serves the functionality of blocking the leakage from the external world.
         5. Safety Detection: If an unreasonable command is sent, safety measures should be enforced.
      3. Noxious Vapor Pod:
         1. Volume: Need to decide a specific volume for the Pod so the design has sufficient space but also not far wasting the design requirement.
         2. Storage Material: We have to decide what kind of material we need to use for the pod, to best prevent the corrosion and erosion from the liquid vapor.
         3. Leaking Detection: There should be a detection device for the tank in case it is leaking.   
            Possible Device: Load Sensor: SparkFun SEN-10245
         4. Leaking Management: At least there should be two layers of walls for the container to make sure that the leakage will not harm the rest of the device. Also serves the functionality of blocking the leakage from the external world. The Leaking management should be more strict here due to the reason that the noxious Vapor is more dangerous.
         5. Safety Detection: If an unreasonable command is sent, safety measures should be enforced.
      4. Mixing Pod:
         1. Volume: Need to decide a specific volume for the Pod so the design has sufficient space but also not far wasting the design requirement.
         2. Storage Material: We have to decide what kind of material we need to use for the pod, to best prevent the corrosion and erosion from the liquid vapor.
         3. Leaking Detection: There should be a detection device for the tank in case it is leaking.   
            Possible Device: Load Sensor: SparkFun SEN-10245
         4. Leaking Management: At least there should be two layers of walls for the container to make sure that the leakage will not harm the rest of the device. Also serves the functionality of blocking the leakage from the external world.
         5. Safety Detection: If an unreasonable command is sent, safety measures should be enforced.
         6. Mixing Device: A mixing rod or more sufficient mixing device needs to exist for sufficient mixing activity.
      5. Mixing System: Pulls small amounts from the needed containers and blends to the set dose. Uses short, clean paths and a quick rinse step to avoid leftover mix.  
         Possible Device: Possible Device: Parallax Standard Servos (x5, White cabinet), a simple stir-rod or pinch-valve actuation.   
         Possible Device: SI1145 (x8, White cabinet/organizer), an optional in-line optical check for mixture clarity/consistency to make sure the mix goes well.  
         Possible Device: Tower Pro MG996 servo

Possible Device: Peristaltic device

<https://www.digikey.com/en/products/detail/adafruit-industries-llc/1150/5638299>

* + 1. Safety System: The last guard against any abnormal commands. If the dose is higher than an amount, this simple safety check system should directly shut down the whole system and warn the user about the failing of the system. A clear hard cap should exist in this component to ensure the last safety guard works correctly.  
       Possible Device: Speaker AST-03008MR-R (x1, White cabinet/organizer), a loud audible alarm on lockout/fault.

Possible Devices: <https://www.sparkfun.com/sparkfun-pulse-oximeter-and-heart-rate-sensor-max30101-max32664-qwiic.html>, https://www.sparkfun.com/pulse-sensor.html

* 1. Powering System: Not exactly sure yet, can be a rechargeable battery but also can be non-rechargeable battery. Should work in normal mode and power saving mode when the system is not activated.   
     Possible Device: Wall→USB 5 V @ 2.1 A — HKA01105021-XE (x1, White cabinet/organizer) which is a primary line supply for benchtop testing. (More likely used for early prototype for simplicity)  
     Possible Device: BQ34Z100EVM (x1, White cabinet), if/when you move to a battery pack, for state-of-charge + low-battery cutoffs.

1. Criteria for Success
   * 1. Sensing: The device reports a saliva or breath nicotine status within 60 seconds and matches a lab reference check in more than 80% of trials; BP and heart rate readings match a reference meter within a small allowed error in bench tests.
     2. Analysis: From any valid sensor or user input, the device gives a clear “status” and “next step” in 10 seconds and always stays within set dose caps and lockouts in a 10 case test set.
     3. Delivery: The system delivers the commanded micro-dose volume (using a safe test liquid) within 10% up and down of target as measured on a scale, and enforces a minimum lockout time between doses every time.
     4. Safety: If a red-flag condition appears (very high BP, sensor fault, low battery), dosing blocks within 1 second and a clear alert shows.
     5. Privacy: the device works with no external network, and the user can erase all local data.
2. Notes: All the parts are still highly abstract so in the process of organizing and implementation, if some of the parts are proved to be impossible to implement or not compatible with the other parts of the system, we reserve the right to re-modify the project and make it still have the best optimal functionality.