Hydration Alert

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Video Link: https://www.youtube.com/watch?v=TYSuz5wQAP4

10/07/2021 - 02/18/2022

Project Summary

Blackstone Valley Vocational High School collaborated with Kelly's Farms to construct a device to notify farmers in the workforce when to hydrate. The "Hydration Alert" is built for rough terrain and is an easy way to integrate hydration into routines. Members of the community in various trades have reported the benefits of feeling healthier and improved moods.

Objective:

- A device that accomplishes the task of alerting labor-based workers to hydrate within specific temperatures.

Materials:

- 9 Volt Battery
- TMP107-Q1 Temperature Sensor Chip
- Arduino Nano
- Adafruit Vibrating Mini Motor Disc
- 3D Print Filament
- 11k Ω Resistor
- Computer with internet access (Google Sheets, flow chart diagram maker)
- Mic Hanger Holder Mount with Adhesive Back
- 5 x 3/7 Fasteners
- Soldering Iron & Solder

Abstract

Our agricultural-based workers are the most dedicated and hard-working individuals and essential people in the workforce in order to maintain a decent quality of life for all. In this technical paper, we dedicated ourselves to helping the well-being of those who have helped us the most. We discovered that over time people on the field tend to dismiss their well-being and do not consume enough water based on their external environment. The clip described in the given document attaches to an individual's hat or belt and alerts them to drink based on the environment they're working in.

Background

In considering tackling common problems those with disabilities may encounter in a work environment, our group reflected on our personal experience and general knowledge. We came to the conclusion that the most prevalent issues are the following: wheelchair accessibility, arthritis, back issues, blindness, diabetes, deafness, ASD, Cerebral Palsy, chronic pain, and amputations. When discussing with our team we all shared stories of those we know who could be experiencing one or more of these issues, one of which was a farmer. When interviewing this man, he began going into some of these issues but then he stepped back and started to emphasize the importance of a much simpler but still extremely prevalent issue. A common conclusion we came to was the potential damage lack of hydration does to the human body. Coming up with a

solution to this would have much more general applicability while also effectively resolving health concerns that arise during extended labor. After discussing with our SME we also observed that some people on the spectrum or with mental deficiencies could benefit from a device that regulates and reminds people to hydrate and take care of themselves.

Interviewing Process

Our SME during the past couple of months is farm owner and retired Engineering Instructor Johnathan Kelly. We reached contact with Mr. Kelly via email prepared with many questions which took place over Zoom due to COVID-19 restrictions. After a conversation with our SME, we decided that the most difficult part of his day is when working on his farm. He reported that due to the long days of manual labor on his farm, he now has a crippling number of physical disabilities because of the conditions and requirements a farm life entails.

As the interview went on, as a team, we documented the following information:

Main Points: Repetitive Stress and Basic Necessities

Biological and Chemical Issues

- ➔ Kidney disease due to the natural frequency of the farm tractor being similar to kidney frequency
- ➔ Dusty Jobs, Lung disease

Tractors and Machinery

- ➔ Going up and down machines over a while cause microfractures and long-term nerve pain.

Obtaining Crops

- ➔ Bending and kneeling became painful
- ➔ Lack of hydration- tendons begin to break down
- ➔ Lack of nutrients and water -tendons begin to break down
- ➔ Reach up and down is affected based on a limited range of motions

Injury

- ➔ Carrying heavy potatoes caused him to fall through the stairs
- ➔ Dropping items leads to injury

Other Factors

- ➔ Vision (sun)
- ➔ Dizziness (heat)
- ➔ Loud sounds
- ➔ Less repetitive stress

Preferences/Wants of SME:

- Would like to reach further with a finer grip than most can provide.
- Elegance and simplicity yet cheap and potentially extendable
- Additional sensing/help with maintaining hydration

Rationale/Brainstorming

In considering what branch of assistive technology our group would undertake. We came to the conclusion that the following industries would be our main concern and interest:

- Amazon Warehouses: Back pain and repetitive physical labor
- Sanitation Workers: Extreme weather conditions, unsanitary environments, and physical strain.
- Home Depot/Koopman's Lumber: Physical labor and consists of a geriatric working population.
- Local Farms: Extreme weather conditions, chemically polluted, strenuous labor, and geriatric population.

After discussing our personal connections with workers in the given fields the most damage we had all observed was the effects of the farming industry in our small town.

Development

Formula for Temperature sensor

When determining the intervals for hydration in relation to the temperature outside, we needed to develop a function that made sense. According to the CDC, an individual conducting manual labor in high heat is recommended to consume water every 15-20 minutes. In cold temperatures, human bodies conserve water in such a way that they feel thirsty roughly 40% less. Using this information, a curve can be approximated with the following assumptions. This creates the graph seen in Figure 1-1, showing the resulting time intervals as a function of the current temperature.

$80°F \rightarrow 20$ minutes

$100°F \rightarrow 15$ minutes

$32°F \rightarrow 140\%$ of $20 = 28$ minutes

$15°F \rightarrow 30$ minutes

For temperatures below 15°F, 30 minutes will be used. In the unusual case of a temperature reading above 120°F, 8 minutes will be used.

Quadratic function created: $-0.0015x^2 + 30$

Piecewise function for realistic end behavior:

$$f(x) = \begin{cases} 30 & \text{if } x < 0, \\ -0.0015x^2 + 30 & \text{if } 120 \geq x \geq 0, \\ 8 & \text{if } x > 120 \end{cases}$$

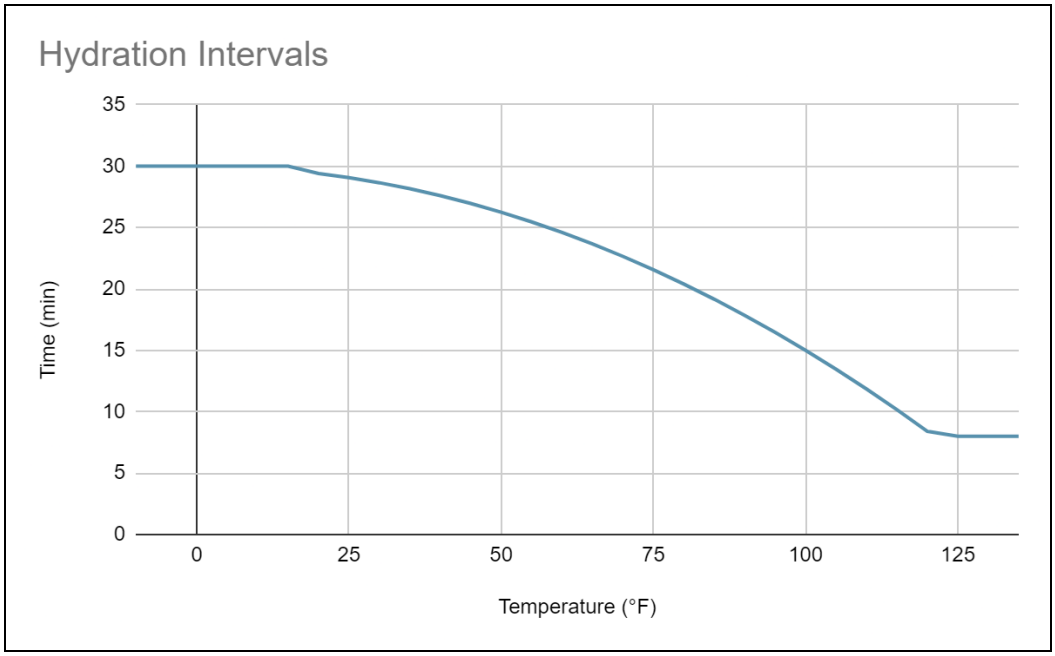


Figure 1-1

Schematic and Protoboarding

On developing our schematic we decided to use an Arduino Nano as the base for our program. We used the 33Ω resistor in order to protect the motor from the exposure of too much voltage, while the 11kΩ resistor was implemented in order to ground the Arduino input pins. When dealing with an Arduino Nano it is important to keep the following in mind:

- D4 is used for our input and D7 as our output pin
- The two GND pins represent ground
- Vin is the voltage input
- A0 as an input for the TMP107
- Pin 17 is a 3.3V supply generated by an on-point voltage regulator

When dealing with the temperature sensor it is important to keep in mind the following:

- Pin 1 is used as the supply voltage
- Pin 5 is used as ground

Our Final schematic and configuration and our final Ultiboard layout can be seen in Figure 1-2.

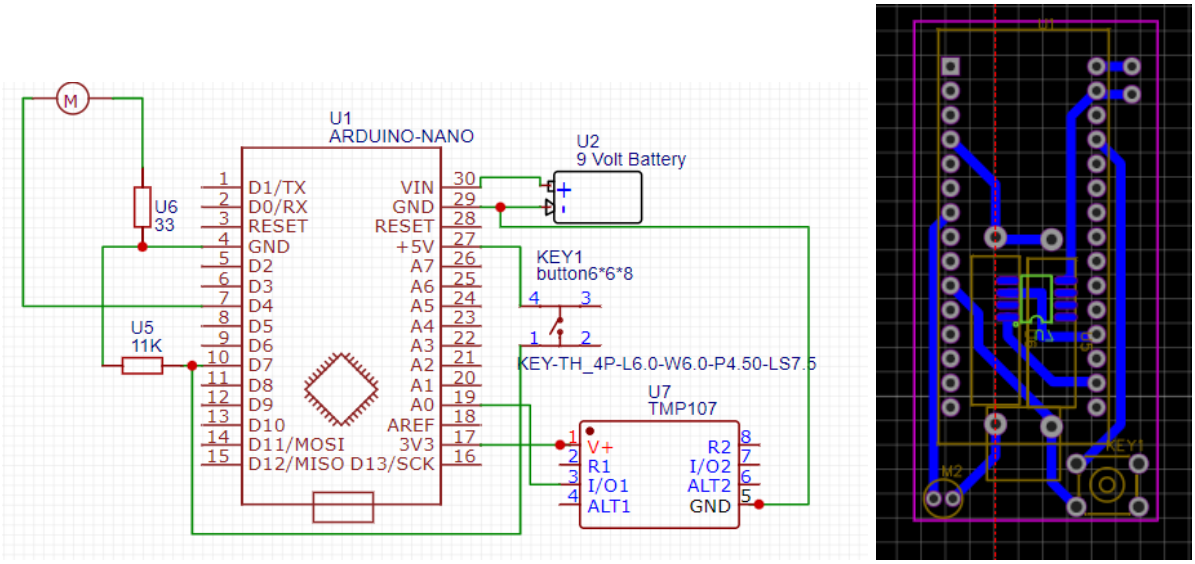


Figure 1-2

Circuit Coding

All software used for the Hydration Alert project can be found at https://github.com/daniel-cardone/hydrationalert.

Upon power being applied to the Arduino Nano, the hardware calibrates the connected TMP107 IC chip according to its documentation, and it initializes pins designated for handling both inputs and outputs. Once this setup process is complete, the TMP107 is used to measure the current surrounding temperature and, according to the equation mentioned previously, sets a timeout for the alert sequence. After this is done, the Arduino continuously loops until the specified amount of time has passed, and once the time has gone by it begins to vibrate according to a defined set of durations creating a pattern. At any point, if the connected SPST switch is pressed, the Arduino receives this information, stops any vibration if it is happening, and readjusts the timeout based on a new temperature reading. This means that the user can press the button every time they drink water, regardless of if the reminder timeout has been completed, and a new time delay will be set. This whole process is displayed visually in Figure 1-3.

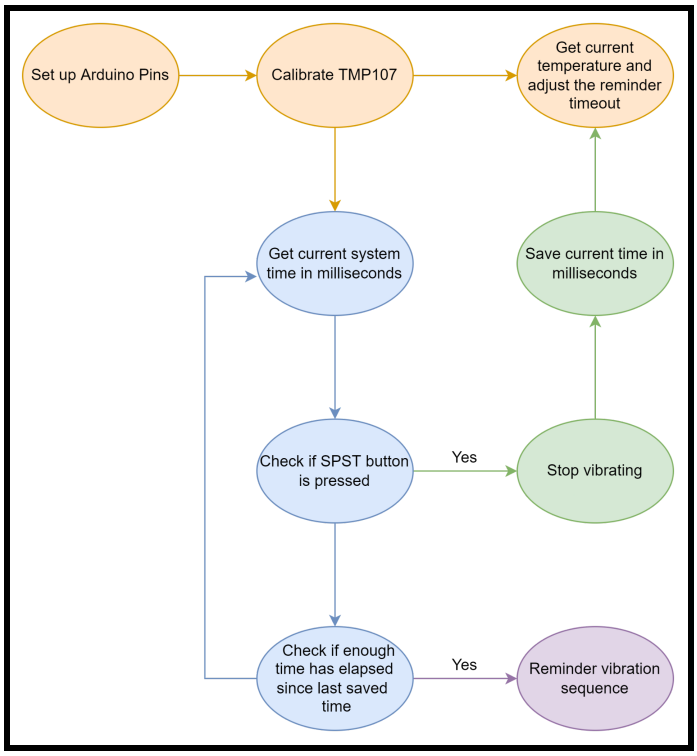


Figure 1-3

Final Design

The final design consisted of a 3D printed box with a clip that can attach to either a belt, hat, sleeve, or shirt. On the inside sits the small PCB with an Arduino Nano, a TMP107-Q1 Temperature Sensor Chip, an 11k-Ω resistor, and a normally open button. This was all encased with a green PLA box and an easily accessible yellow button to stop the reminder vibrations. On the back of the box is attached a metal clip, and on the side of the box is a hole extruding a battery holder with a clip on the back of the holder.

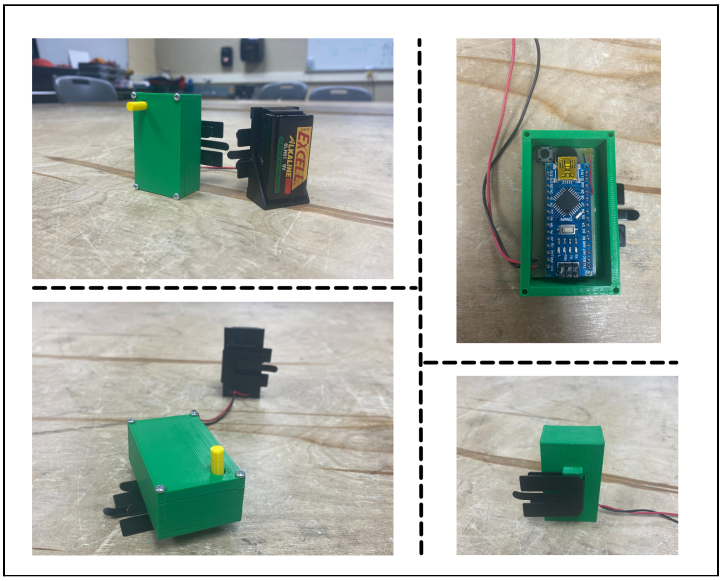


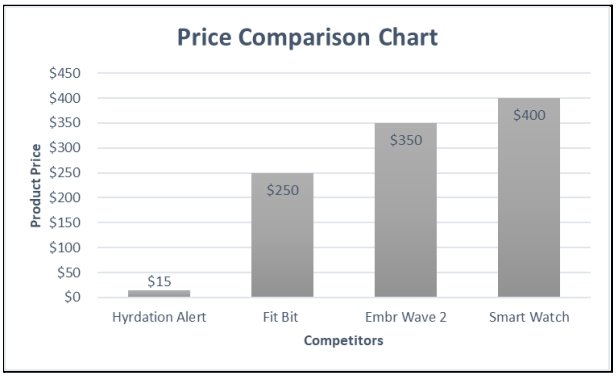
Figure 1-4

Cost Analysis

In considering the cost analysis for the materials used for this product we considered the unit price and bulk price which is documented in Figure 1-5. The overall cost including labor was evaluated and included for the overall cost of production for our overall product and compared to our "competing" companies that measure that remind individuals to hydrate based on their given environment and a pie chart was created for creating a visual of the overall cost in bulk. These two can be seen in Figure 1-5 and Figure 1-6.

Item	Unit Price	Bulk Price
9V battery snap	$1.02	$1,020,000
1TMP 107-Q1	$1.48	$1,480,000
Arduino Nano	$0.11	$110,000
DC Vibration Motor	$0.40	$400,000
Normally Open Digital Electronics Button	$0.06	$60,000
33 ohm Resistor	$0.02	$20,000
11k ohm Resistor	$0.01	$10,000
Clip	$2.25	$2,250,000
PLA Box	$0.00067	$666.875

Figure 1-5



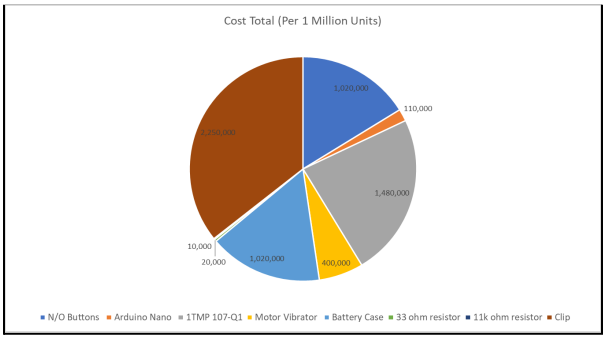


Figure 1-6

Testing Procedure/Results

Student Testing

NOTE: Individuals must test out the device on either belt or shirt and be equipped with water near them.

Running Procedure: Completing a jog up and down a set of stairs for 30 seconds to test vibration during physical activity and the strength of the clip coupled with how bulky the clip may be.
Climbing Procedure: Completing climb up and down different elevations for 15 seconds to test vibration during physical activity and the strength of the clip coupled with how bulky the clip may be.

Group Member	Running Results	Climbing Results
Owen Atkins (Pocket)	"I did notice the device in my pocket but it was light enough to not impress with activities."	"Same as the running, I could feel the device in my pocket but it felt more secure due to less motion"
Daniel Cardone (Collar)	"Although I could definitely feel it against me, there was no noticeable movement while I ran and it doesn't provide any real discomfort."	"Attached to the collar, the vibration was very noticeable and could not be ignored. It stayed on through the whole test. A drop test was also performed from roughly 5 feet, and the device continued performing as if nothing happened."
Natalia Vazquez (Waistband)	"The metal clip was tight enough not to budge. I didn't feel shaking, and it was surprisingly lightweight. The product didn't feel like it was shaking around or weighing me down."	"The vibration was noticeable but not bothersome, but given the incline stayed a little less stable."
Kate Watchmaker (Waistband)	"Nothing was rubbing against my skin and it was surprisingly sturdy on my belt. I was very impressed how well it stayed on as I was running up and down stairs."	"Became a little less stable due to higher elevation but was prominent enough vibration to alert me"

Figure 1-7

Community Impact

NOTE: Due to COVID restrictions our original SME was unable to try our product
SME: Russel Boisvert
Profession: Vocational Instructor
Experience: After a wire break while attaching to a belt loop, the device was repaired and was re-installed. Within minutes, I forgot it was there until I felt the vibration reminding me to drink. I continued to wear the device during my normal work activities from approximately 8 am until 4 pm. The device did not catch on anything and was only noticeable to me when the vibration

reminder activated. After completing this I drank a couple of sips of water approximately every 20 minutes and it infinitely impacted my mood and had me feeling more energetic.

Conclusion

Assistive Technology will always remain a relevant and necessary field to all of us and this opportunity has created an opportunity for our group to take on in this battle one device at a time. Through brainstorming and troubleshooting, the Hydration alert is bound to make an impact on not only farmers but all who want to be more hydrated and develop a more effective routine in their lives. It is clear that dehydration can have lasting effects a person's health, and through our device using a sensory-based reminder that clips lightly onto a clothing article, coupled with an easily accessible button, this can easily be avoided.

References

- *Heat Stress: Hydration - Centers for Disease Control and ...* https://www.cdc.gov/niosh/mining/UserFiles/works/pdfs/2017-126.pdf.

Acknowledgments

We thank our vocational instructors Micheal Norton and Russel Boisvert for their continued dedication in providing us with the resources we need and constructive feedback on our Assistive Technology Product. These resources included a 3D printer, PCB maker, soldering irons, and Electronic components. We also thank our SME Johnathan Kelly for his personal experience, time, recommendations, and countless contributions to our community.