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Breath Free – Screening stress and anxiety from breathing pattern

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Abstract -Stress and anxiety are two of the most common problems faced by many people-which can affect a person's breathing pattern and bad breathing causes more serious problems. Our product aims to detect early stress and anxiety using breathing as a vital sign. After a lot of research, we found out that the best non-invasive way to measure a person's breathing rate is by measuring their chest and belly expansion. To make our prototype compact and easy to wear we made two rectangular 3D Printed box like structures and fitted them with FSR sensors to measure the chest and belly expansion. It is a wireless device that connects with the computer via bluetooth dongle and sends the data serially. We are using a python program which collects the data and generates
A4 size infographic report of the breathing that includes chest and belly breathing pattern, consistency and flow of breathing, breathing rate, number of deep, shallow and normal breaths.

While testing the device we found that the breathing pattern of working professionals engaged in stressful jobs is different from that of a school going kid. We have also tested our model for-gaming activities to test the excitement and stress as it can affect our breathing. We found that breathing pattern and breathing rate changes while gaming and similarly in work culture, stressful jobs and environments affects our breathing pattern.

Dr. Ayushi Shah told us that stress and anxiety directly affect-breathing patterns which leads to other problems due to lack of oxygen in the body and blood circulation. But it can be controlled by proper physical practices. Our device can be a breakthrough in implementing the same

Keywords- breathing pattern, chest and belly expansion, breathing rate, detect early stress and anxiety, lack of oxygen, Screening Breathing, Monitoring stress level

1. Introduction:

Breathing is the most common vital sign but not considered important as it is both subconscious and conscious. It can tell us a lot about our body like diseases and mental stress and anxiety. Mental stress and anxiety has a very bad effect on our breathing as people under stress do shallow breathing. The respiration rate for an adult at rest is 12 to 20 breaths per minute. A respiration rate over 25 breaths per minute while resting is considered abnormal. A person who is suffering from anxiety and stress can have breathing issues. During a panic attack one will experience chest tightening, shortness of breath, and faster breathing because your body is trying to get more oxygen to your muscles. During stress the body pumps blood quickly to all the organs in the body due to which one can experience shortness of breath.

The main goal of this project is to create a lifestyle device to help humans monitor their stress and anxiety using the most common vital value associated with it, which is breathing. It aims to create an accurate way to measure your breath directly unlike other products that use pulse rate to measure your breath. It aims to record and process all this data to aid the user in understanding the severity and the effects of stress and

anxiety on breathing pattern and body. It provides a simple and easy to understand report and data sheet explaining the credentials related to their breathing.

1. **Depression**

Depression can cause feeling sad or "empty", loss of interest in favorite activities, overeating, or not wanting to eat at all, not being able to sleep, or sleeping too much, feeling very tired, feeling hopeless, irritable, anxious, or guilty, aches or pains, headaches, cramps, or digestive problems and thoughts of death or suicide.

Stress

Stress can be defined as any type of change that causes physical, emotional, or psychological strain. Stress is your body's response to anything that requires attention or action. Everyone experiences stress to some degree.-

Stress can be short-term or long-term. Both can lead to a variety of symptoms, but chronic stress can take a serious toll on the body over time and have long-lasting health effects.

Some common signs of stress include:

1. Changes in mood
2. Clammy or sweaty palms
3. Diarrhea
4. Difficulty sleeping
5. Digestive problems
6. Dizziness
7. Feeling anxious
8. Frequent sickness
9. Grinding teeth
10. Headaches
11. Low energy
12. Muscle tension, especially in the neck and shoulders
13. Physical aches and pains
14. Racing heartbeat
15. Trembling

Stress is not always easy to recognize, but there are some ways to identify some signs that you might be experiencing too much pressure. Sometimes stress can come from an obvious source, but sometimes even small daily stresses from work, school, family, and friends can take a toll on your mind and body.

If you think stress might be affecting you, there are a few things you can watch for:

Psychological signs such as difficulty concentrating, worrying, anxiety, and trouble remembering

Emotional signs such as being angry, irritated, moody, or frustrated

Physical signs such as high blood pressure, changes in weight, frequent colds or infections, and changes in the menstrual cycle and libido

Behavioral signs such as poor self-care, not having time for the things you enjoy, or relying on drugs and alcohol to cope

Causes

There are many different things in life that can cause stress. Some of the main sources of stress include work, finances, relationships, parenting, and day-to-day inconveniences.

Stress can trigger the body’s response to a perceived threat or danger, known as the fight-or-flight response. During this reaction, certain hormones like adrenaline and cortisol are released. This speeds the heart rate, slows digestion, shunts blood flow to major muscle groups, and changes various other autonomic nervous functions, giving the body a burst of energy and strength.

Originally named for its ability to enable us to physically fight or run away when faced with danger, the fight-or-flight response is now activated in situations where neither response is appropriate—like in traffic or during a stressful day at work.

When the perceived threat is gone, systems are designed to return to normal function via the relaxation response. But in cases of chronic stress, the relaxation response doesn't occur often enough, and being in a near-constant state of fight-or-flight can

cause damage to the body.

Stress can also lead to some unhealthy habits that have a negative impact on your health. For example, many people cope with stress by eating too much or by smoking. These unhealthy habits damage the body and create bigger problems in the long-term.

Anxiety

Anxiety is the mind and body's reaction to stressful, dangerous, or unfamiliar situations. It's the sense of uneasiness, distress, or dread you feel before a significant event. A certain level of Anxiety helps us stay alert and aware, but for those suffering from an anxiety disorder, it feels far from normal - it can be completely debilitating.

Types of Anxiety Disorders

1. Anxiety disorders: Anxiety disorders are characterized by a general feature of excessive fear (i.e. emotional response to perceived or real threat) and/or anxiety (i.e. worrying about a future threat) and can have negative behavioral and emotional consequences.

2. Obsessive-compulsive and related disorders: Obsessive-compulsive and related disorders are characterized by obsessive, intrusive thoughts that trigger related, compulsive behaviors . These behaviors are performed to alleviate the anxiety associated with obsessive thoughts.

3. Trauma- and stressor- related disorders: Trauma- and stressor- related anxiety disorders are related to the experience of a trauma (e.g., unexpected death of a loved one, a car accident, or a violent incident like war or sexual assault) or stressor (e.g., divorce,
beginning college, moving)\

Causes and Risk Factors

- Comorbidities
- Genetics
- Environment Factors
- Medical Condition
- Behavioral Choices
- Demographics

Literature review:

During my research, I have considered stress and anxiety as the main core problem and researched about the present solutions available to tackle or help in dealing with stress and anxiety. There are many software solutions available which helps on the stress and anxiety but most of them goes with therapeutic approach

Stop, Breathe, Think

This app was created by the folks at the nonprofit Tools For Peace, which teaches mindfulness and meditation to teens and empowers them to become more compassionate. Developed for adults, teens, and children, it is perfect for when you're overwhelmed by intense emotions like anxiety, stress, sadness, or anger. When you notice intense feelings arise, you can turn to the app, and it guides you through the practice of stopping, calming your mind and body through breathing, observing your thoughts, and then participating in a short meditation.

Calm

An Apple Best of 2018 award winner, Calm's offerings run the gamut from masterclasses (on things like creativity and holistic health) and guided videos on stretching, to sleep stories (think soothing bedtime stories for grownups) and meditation series that address specific areas in life, like anxiety, focus, self-esteem, and self-care. There are meditations for college students and meditations and sleep stories for

kids as well. Each day, there is a new "Daily Calm" meditation with a different theme, and you can track the number of days and minutes you meditate.

Aura

This app pairs your current mental state with the best meditation or relaxation strategies to help you reduce stress and anxiety, improve sleep, as well as increase happiness. Aura offers guided meditation

Respa:

RESPA is an easy-to-use wearable sensor that tracks your breathing for the duration of your workout. With the RESPA companion app, you can train smarter and practice better as you get real-time alerts for staying in optimal breathing zones.

Our Solution

Our solution is really simple and small. We have made a non-invasive wearable device called BREATHEFREE. Which monitors the breathing pattern to track the stress and anxiety

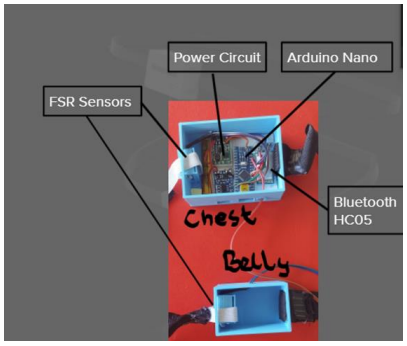
•It consists of 2 3D printed boxes one being for the chest and the other one being for the belly.

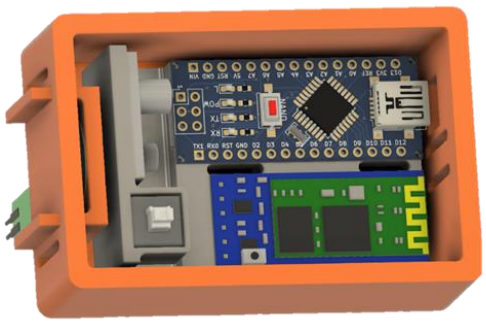
•It has Force sensitive resistors - FSR to measure the pressure created by chest and belly expansion during breathing

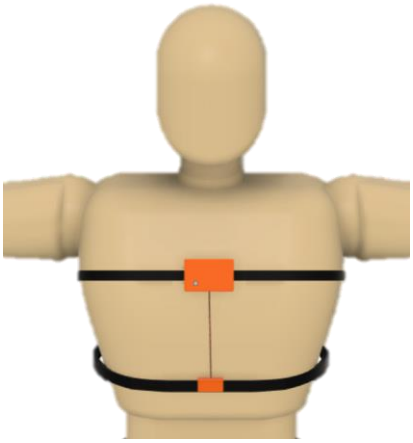
•It generates a infographic report of the breathing test

Method

Our prototype model uses the following components: Arduino nano, HC05 Bluetooth module, DC to DC power booster, 10000 milli Amph lithium ion battery HC05, TP4506, FSR sensor. The strap loops around the FSR sensor inside the 3D printed case so that whenever there is a push or pull on the strap data is received. This strap is an elastic strap and is supposed to be tied around your chest. There is a second module to this prototype which is connected via wire and is supposed to be tied around the belly. This module only contains the FSR unit of the previous module. This data is sent through the Arduino Nano which sends it to the Bluetooth module. The Bluetooth module transfers this data to the master Bluetooth module (Phone, laptop) in which a python code is used to process the data. The data is bound together into a comma separated value file. This file is then put into an excel sheet. Next using the matplotlib import, we convert this data into a graph format. This data is later processed to calculate multiple useful quantities like breathing rate and consistency and many more. This is done using the crests and falls of the graph. Each crest and fall is considered as one breath. This determines the breathing rate and the average of the change in time between crests denoted the consistency in a percentage. We also calibrate the sensor to measure and hence record breaths in only a certain range





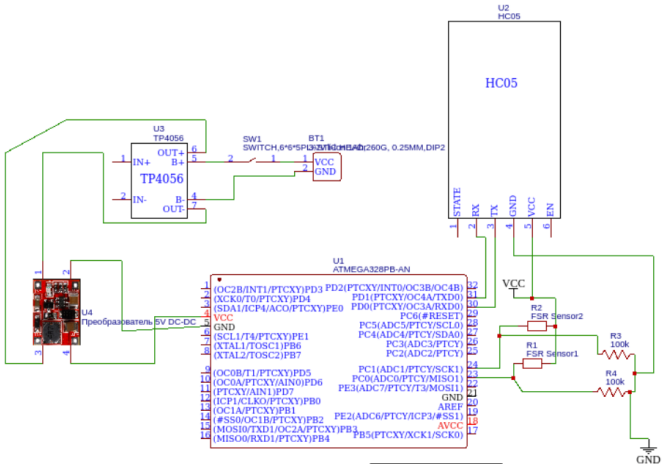


After a lot of trial and error and research we found out that there are many different ways to find out your breathing pattern. Like using fitness bands, special masks which are used by athletes and some recently developed products like respa which work on microphones and gyroscopic sensors, are not that reliable and cannot provide a very good resolution of data. But there is no solution available that can help you correlate and measure the severity of stress and anxiety and its effect on the body from bad breathing pattern

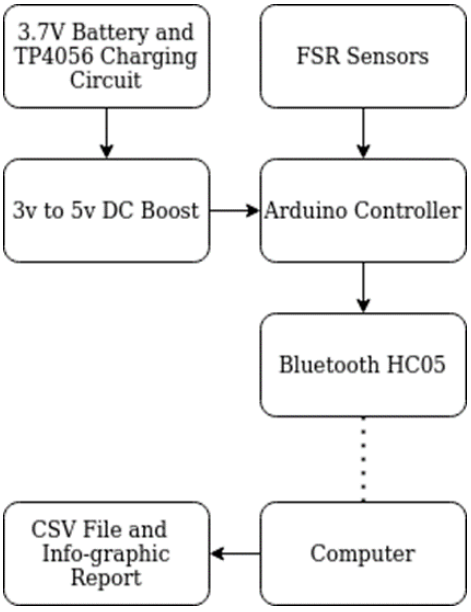
The best way we found to measure our breathing rate is by measuring our chest and belly expansion which we are able to do with the help of our prototype. We are directly monitoring a person's breathing rate by placing it on their chest and belly.

Our solution provides a very easy to read report which consists of a pie chart showing the different types of breathing patterns, a bar graph which shows the consistency and the gap between the breaths, a line graph showing the pattern of chest and belly breathing , no of different types of breaths taken like deep, normal, and shallow and the overall breathing score.The novelty of our solution is that it directly generates a report from the chest and belly expansion data therefore making our prototype much more accurate and it is very cheap as our prototype only costs ₹4300.

Circuit Diagram:



Flow Chart:



Components:

Item	Price ₹	Quantity
Dc to dc powerhouse	50	1
Fsr sensor	700	2
Lithium ion battery 1000mah	450	1
Complete set printing	1500	1
Hc-05 bluetooth	850	2
Charging module (Tp4056)	50	1

Force Sensor Resistor

Dc to dc micro boost 5v

Lithium ion battery 3000maH

Hc-05(bluetooth module)

Charging module

Arduino nano

Algorithm

The Arduino code is collecting the data to send it to a specific com port via bluetooth. The python algorithm is used for data collection and report generation. Over here we use the libraries FPDF, pandas, matplotlib, numpy, time, sys, serial and datetime.

We start with basic questions like gender, age, and name. We use a constant loop to check the FSR sensor values and print the values as well as store them on an excel sheet. We divide values into 2 which is the chest and belly data Next is the data processing. For the first 10 seconds of the code it calibrates your breathing and sets threshold values for the minimums and maximums of your normal and deep breaths. We do this using the lowest and highest of your normal breathing and set those thresholds. We then check

using another while loop, whenever you cross the maximums for either normal or deep breath the breath counter is increased. We used the flag method to do proper counting of breaths. This flag system only allows a breath to be counted when it has gone under the minimum checker and resets the flag when it goes above a calibrated threshold. We then calculate the breaths per minute by taking the time in seconds, divide it by 60 and divide that value by the total number of breaths. We use all of the values and put it in a report with a graph of the raw breathing values using the matplotlib library. We use the fpdf library to generate our report. Our program generates a A4 size printable report that has graphs of breathing pattern of chest and belly, along with that consistency bar graph and a pie-chart of types of breaths. It also has all the important credentials of the patient

Algorithm :

Program :
“”: Finding Thresholds
“”: Finding count of each type of breath
“”: Creation of pdf report

/////

```
while True:
            try:
        read=ser.readline().decode("utf-8") #
left
            except UnicodeDecodeError:
        print('unicode error')
            x = read.strip('\n\r')
            y = x.split(',')
    temp.append(int(y[1]))
            belly_temp.append(int(y[2]))
            diff = float(y[0]) - t1
            if diff > 10000:
            break
            # stop after some time
            # add code here

min_chest = min(temp)
max_chest = max(temp)
threshhold = (min_chest+max_chest)/2
belly_threshhold =
(min(belly_temp)+max(belly_temp))/2
while True:
            try:
        read=ser.readline().decode("utf-8") #
left
            except UnicodeDecodeError:
        print('unicode error')
            else:
            x = read.strip('\n\r')
            y = x.split(',')
            t1 = float(y[0])
```

(This is the phase where we take resting breathing values for 10 sec and find thresholds by using minimums and maximums of the array)

```
while True:
            try:
        read=ser.readline().decode("utf-8") # left
            except UnicodeDecodeError:
        print('unicode error')
            x = read.strip('\n\r')
            y = x.split(',')
            diff = float(y[0]) - t1
            print(x)
# deep breathing count
            if int(y[1])>max_chest+10 and flag:
        deep_breadth = deep_breadth + 1
            flag = False
        print("->>>>>>>>>>>>>>>>>>>>>> deep
triggered")
             if int(y[1])<max_chest-10 and not(flag):
            flag = True
# breathing through chest count
            if int(y[1])>threshhold+10 and
chest_flag:
        chest_breadth = chest_breadth + 1
        chest_flag = False
        print("----------------------------------------->
chest triggered")
        rhythm_arr.append(float(y[0]))
            if int(y[1])<threshhold-10 and
not(chest_flag):
        chest_flag = True
# breathing through belly count
            if int(y[2])>belly_threshhold+15 and
belly_flag:
              belly_breadth = belly_breadth + 1
        belly_flag = False
        print("----------------->belly triggered")
```

```
        if int(y[2])<belly_threshhold-15 and not(belly_flag):
            belly_flag = True
```

Over here we use the flag system of checking to check and count the different types of breath

```
pdf.set_font('Arial', '',16)
pdf.cell(100, 10, 'Age - '+str(age), ', Gender - '+str(gen),0,0)
pdf.set_font('Arial', 'B', 25)
pdf.cell(140,10,'Breathing Score - ',0,0)
pdf.set_font('Arial', '',16)
pdf.cell(40,10,'Time- '+str(date.hour)+':'+str(date.minute),0,1)

pdf.set_font('Arial', '',14)
pdf.cell(100, 8, 'Deep Breaths - '+str(deep_breadth),0,1)
pdf.cell(100, 8, 'Chest Breaths - '+str(chest_breadth),0,1)
pdf.cell(100, 8, 'Belly Breaths - '+str(belly_breadth),0,1)
pdf.cell(100, 8, 'Shallow Breaths - '+str(shallow_breadth),0,1)
pdf.cell(100, 8, 'Total Breaths - '+str(total_breadth),0,1)
pdf.cell(100, 8, 'Breathing Rate - '+str(total_breadth/2),0,1)
pdf.cell(100, 25, '',0,1)
pdf.image(name+'report.png',70,40)
pdf.set_font('Arial', 'B',14)
pdf.cell(100, 20, 'BELLY BREATHING PATTERN ',0,1)
pdf.cell(100, 25, 'CHEST BREATHING PATTERN ',0,1)
pdf.set_font('Arial', 'B',20)
pdf.cell(100, 20, '',0,1)
pdf.cell(100, 10, 'Consistency ',0,1)

pdf.set_font('Arial', '',14)pdf.cell(100, 8, '(Average - 9)',0,1)


# pdf.cell(500,10,'Age - 25, Gender - Male')
# pdf.cell(500,30,'Age - 25, Gender - Male')
pdf.output(name+'report.pdf', 'F')

plt.show(
```

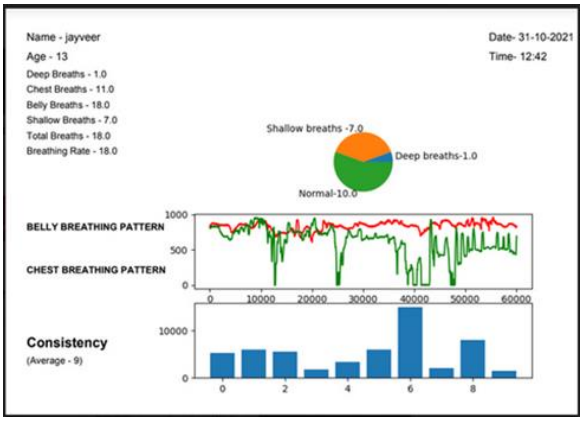
Over here we have used the fpdf library import to create tables and graphs and make a pdf report

Testing

We tested the prototype on many different corporate employees and children like us and we found that the resting breathing pattern of a corporate person who is stressed is faster than a kid's breathing rate by 5 to 6 breaths and found out that they perform much more shallow breathing than children. Even their consistency is very poor with big fluctuations.

Result and observation:

During stress a person's breath increases as the body pumps blood to the organs faster, which readies the muscles for action. It also causes a person to breathe more quickly to provide more oxygen to the muscle.



This is a normal 1 minute test report that we have recorded while the subject was gaming

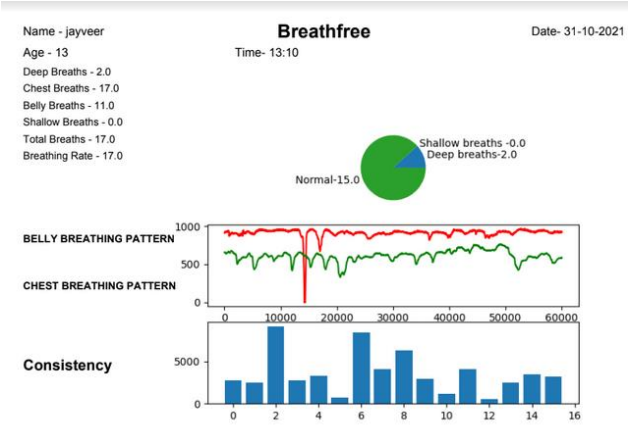
Normal Breaths - 11

Deep Breaths - 1

Shallow Breaths - 7

Consistency - below average

As you can see that in this test there are 7 shallow breaths confirming that breathing is affected by stress



This is a normal 1minute test report that we have taken at resting position

Normal Breaths - 17

Deep Breaths - 2

Shallow Breaths - 0

Consistency - normal

As you can see that in this test there are no shallow breaths as the subject was at rest

Acknowledgement :

Dr. Ayushi Shah, from Mumbai has helped us in understanding the problem in a better way to improve our project idea and output. We had several online meetings with her where we discussed the progress of our project and its results from time to time.

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Future Scope

In the future we are going to do a range of improvements on our prototype like performing improvisation by using machine learning so that it can be used as medical device in the medical field, as a screening device for checking if anyone has a respiratory disorders and can be also used as a lifestyle device to measure a person's breathing pattern while they do some exercise or do yoga. Also the report produced would be more accurate and a little more easier to understand. Lastly, we are looking to provide our solution in different sizes and make it a bit more comfortable.

Conclusion:

To conclude, Our device has the capability to detect shallow breathing, consistency as well deep breaths. We tested this on multiple people - employees, people who were gaming at rest and of multiple different age groups.

Using all that data it becomes very easy to predict the effect of stress on breathing through this device. During stress a person's breath increases as the body pumps blood to the organs faster, which readies the muscles for action. It also causes a person to breathe more quickly to provide more oxygen to the muscle.

We showed that data to Dr Ayushi Shah who told us that the data collected can be very helpful to doctors. It can also be very helpful to check if a person has stress or anxiety as during anxiety/panic attacks the person's breathing rate rapidly increases and they start taking shallow breaths.

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