

BML 300: INTRODUCTION TO HEALTHCARE ENGINEERING

Coordinator: Dr. Arnab Chanda

Centre for Biomedical Engineering, IIT Delhi

Department of Biomedical Engineering, AIIMS Delhi

Date: Oct 04, 2024

CONTENTS

- 1. Introduction**
- 2. Market**
- 3. State of the Art**
- 4. Commercialized Indian Technologies**
- 5. Challenges**
- 6. Solution Driven New Indian Technologies**
- 7. Future Opportunities**

INTRODUCTION

▪What is a Wearable Technology?

- Smart electronic devices
- Worn close to skin or placed on body contact surfaces (e.g. Chair)
- Can detect, analyze, and transmit body signals continuously:
 - Physical activities and behaviour (e.g., steps, energy)
 - Physiological parameters (e.g., body temperature, heart rate)
 - Biochemical Parameters (e.g., pH, glucose)
- Smart Phone to collect data and store on remote server

▪Wearable Technology: What comes to mind?

-A Fitbit



FITBIT
FB507BKBK Versa 2 Unisex Smart Watch
Sold By: Titan Company Ltd
₹17,849 ₹20,999 15% OFF
[BUY NOW](#) [A](#)
DELIVERY OPTIONS
Please enter your pincode to check for available delivery
 [CHECK](#)

-Apple watch



Apple Watch Series 5 (GPS, 40mm) -
Silver Aluminium Case with White Sport Band
Visit the Apple Store
929 ratings | 817 answered questions
Price: ₹ 40,900.00 [8 Fulfilled](#) FREE Delivery, Details
Inclusive of all taxes
Delivery by: Wednesday, Sep 23 Details
EMI starts at ₹1,925. No Cost EMI available EMI options
In stock.
Sold by Appario Retail Private Ltd and Fulfilled by Amazon.
10-day replacement only
Colour: Silver Aluminium Case with White Sport Band

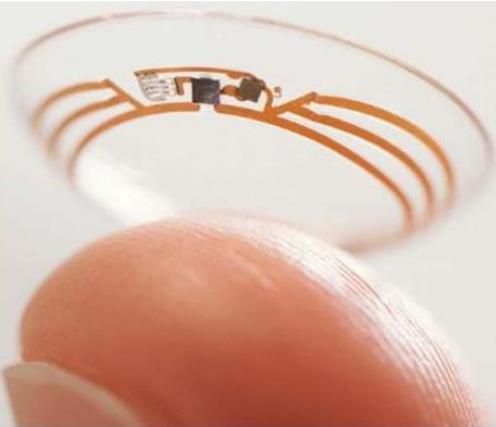
Size name: 40mm
40mm 44mm
Style name: GPS

INTRODUCTION

- **Wearable Technology is a LOT MORE than Fitbits and Apple Watches**

1. Prevention of diseases and maintenance of health
2. Patient Management
3. Disease Management

- **Most wearable technologies still in prototype stages**



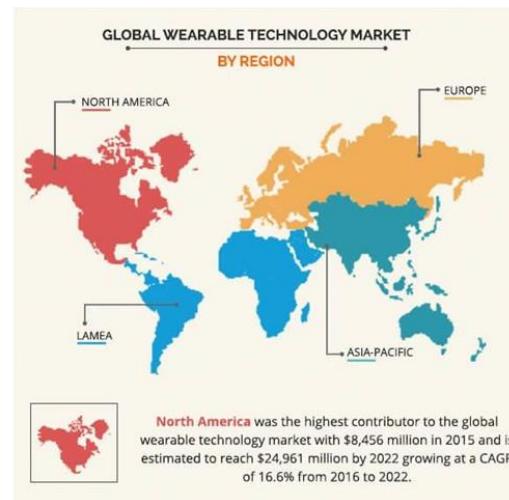
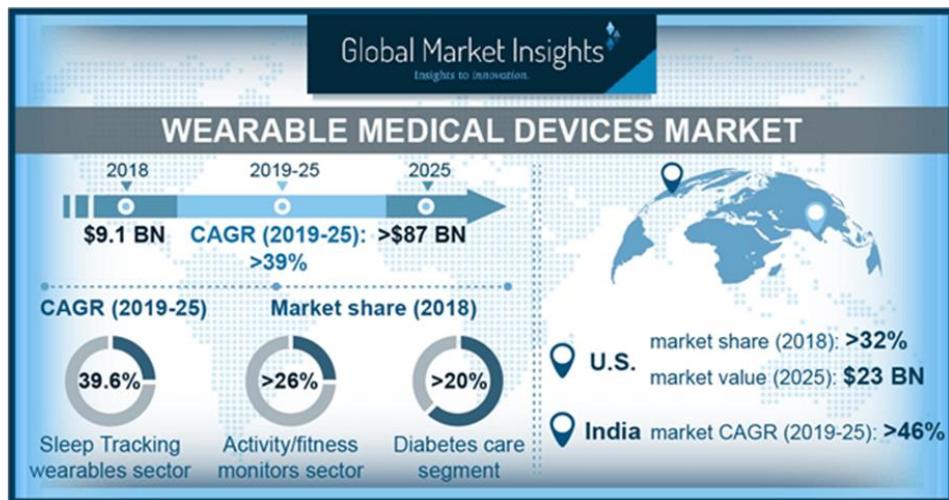
- **Issues to be Resolved: User acceptance, security, ethics**

MARKET

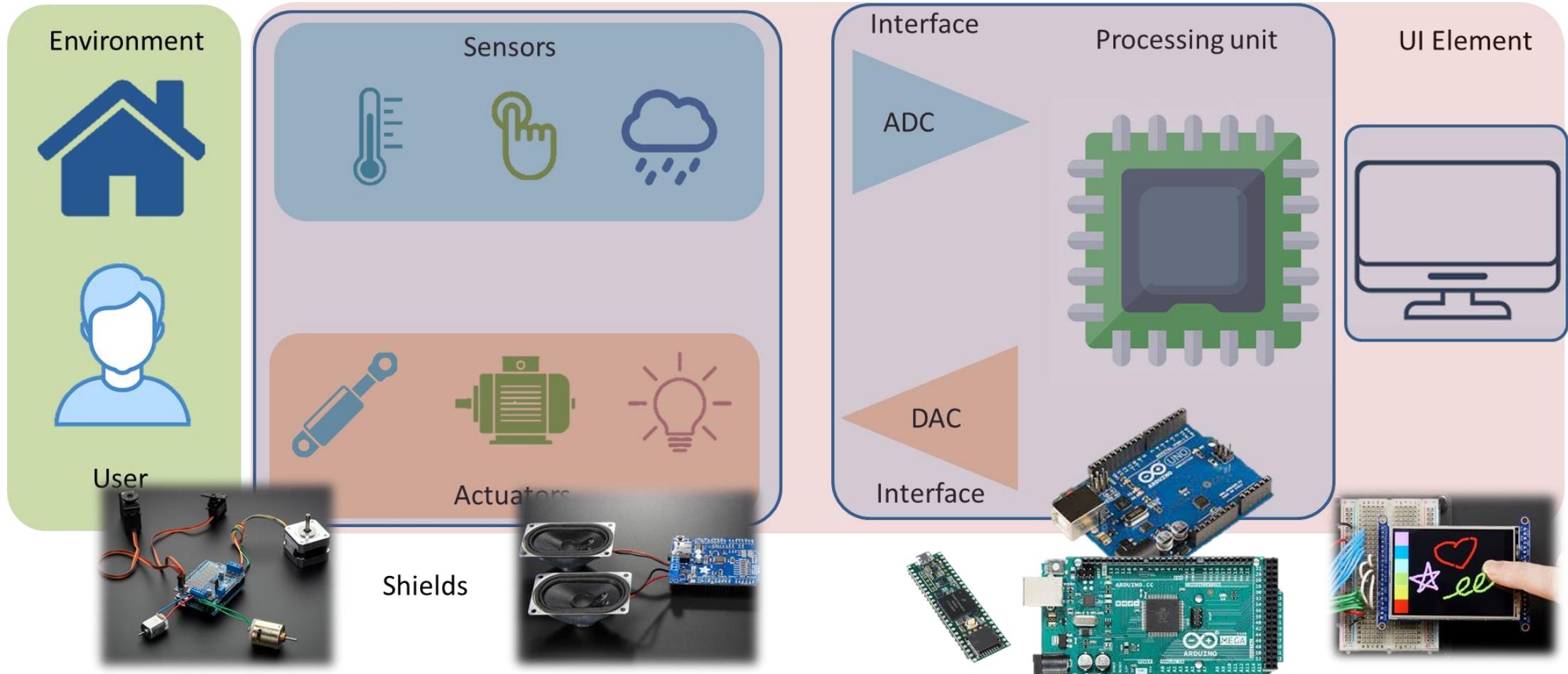
▪What is the Market?

- Majority market in USA
- Untapped Indian Market (CAGR>46%)

▪By 2025, \$87 Billion (Rs. 64,04,08,30,50,000)



The Arduino revolution – democratizing hardware



Built-in and third-party libraries for hardware control

NO Datasheet, NO hardware expertise required

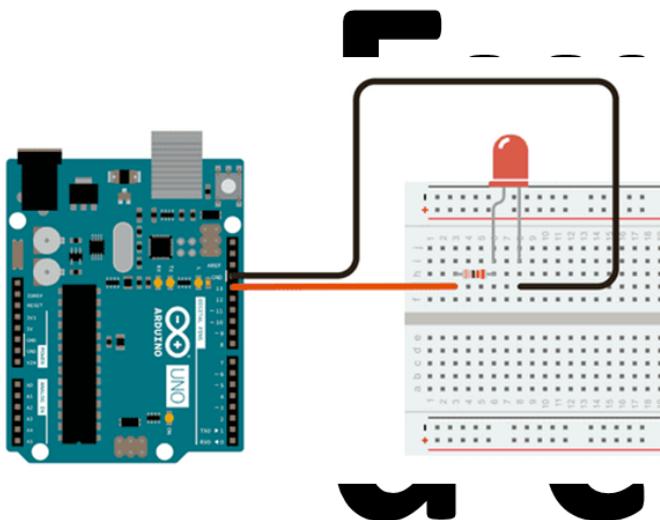


Table 11-2. Reset and Interrupt Vectors		
BOOTRST	IVSEL	R
1	0	0x
1	1	0x
0	0	Bk
0	1	Bk

Note: 1. For the BOOTRST fuse

The most typical and general program:

Address	Labels C
0x0000	j
0x0002	j
0x0004	j
0x0006	j
0x0008	j
0x000A	j
0x000C	j
0x000E	j
0x0010	j
0x0012	j
0x0014	j
0x0016	j
0x0018	j
0x001A	j
0x001C	j
0x001E	j
0x0020	j
0x0022	j
0x0024	j
0x0026	j
0x0028	j
0x002A	j
0x002C	j
0x002E	j
0x0030	j
0x0032	j
...	...
0x0033	RESET: l
0x0034	o
0x0035	l
0x0036	o
0x0037	a
0x0038	<instr>
...	...

```

org 00h
SETB 20H
MOV TMOD,#01H

START:
    MOV R0,#14H
    MOV TH0,#4BH
    MOV TL0,#OFFH
    SETB TR0

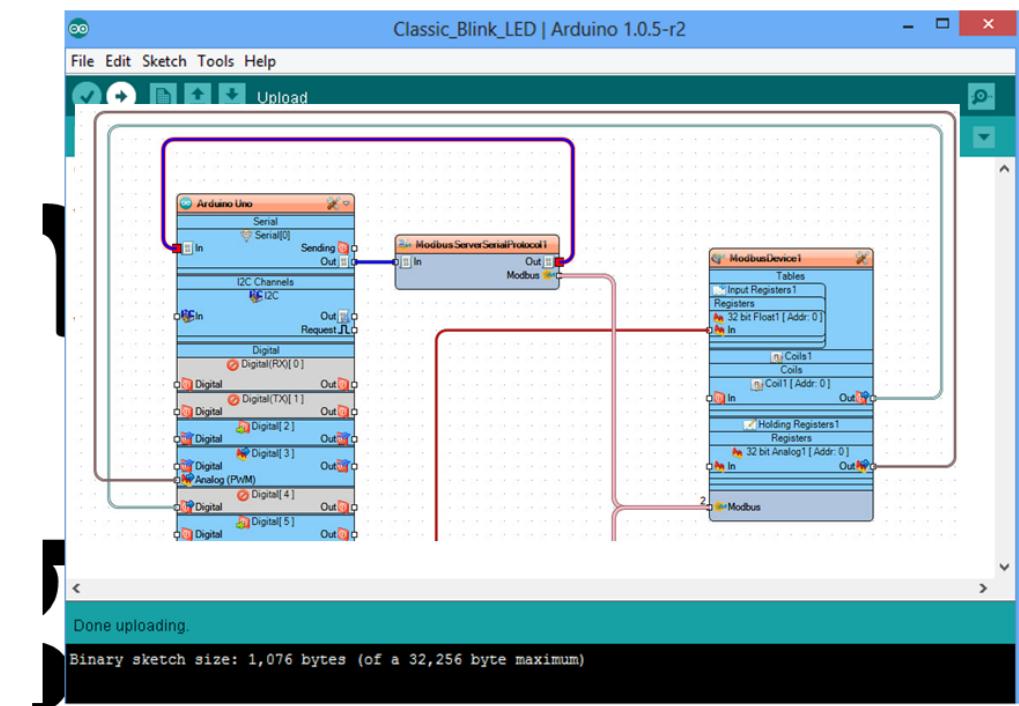
INIT:
    MOV TH0,#4BH
    MOV TL0,#OFFH
    JNB TFO,$
    CLR TFO
    DJNZ R0,INIT
    JB 20H,LEDON
    JNB 20H,LEDOFF

LEDON:
    MOV P1,#00H
    CLR 20H
    JMP START

LEDOFF:
    MOV P1,#OFFH
    SETB 20H
    JMP START

end

```



STATE-OF-THE-ART

Prevention of Diseases and Maintenance of Health

1. Fall Identification and Prevention

Challenges

- Providing care to an aging population has become a significant challenge
- Global elderly population >60 yrs will be >2 billion by 2050 (WHO)
- Increased risks for falls (>60%), injuries, and deaths

Solution

- Active gait (manner of walking) monitoring
- Active warning for wrong walking patterns
- Fall detection (using accelerometer)
- Alerting family/hospitals



Prevention of Diseases and Maintenance of Health

2. Weight Control and Monitoring

Challenges

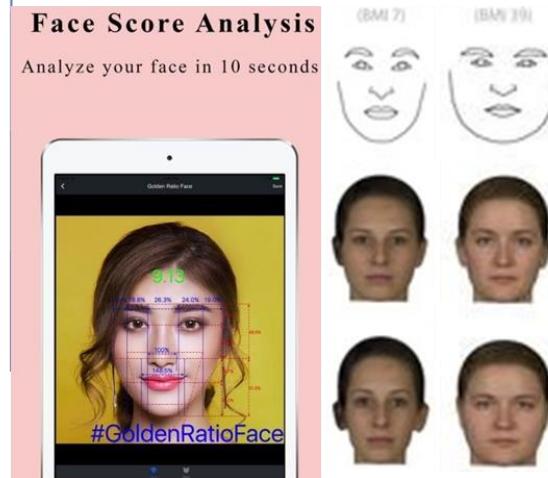
- Over 73% urban Indians are overweight
- Risk Age: 28-38 yrs
- Increased risks for:
 - Diabetes (Risk of heart, kidney, nerve damage)
 - Heart Disease (Stroke)
 - Osteoporosis (weakening of bones)

Solution

- Lack of reliable wearable device
- Recent research on Face Pictures→Obesity
- Physical activity monitor (Not reliable)
- Eating monitor (Not reliable)



73% of urban Indians are overweight
Almost 3 out of 4 Indians are overweight
Almost 1/2 urban Indians are obese!
Max Risk Age: 28 – 38 yrs
Highest risk of weight gain, for men & women
Average person goes from healthy at 26 to obese at 38 yrs.



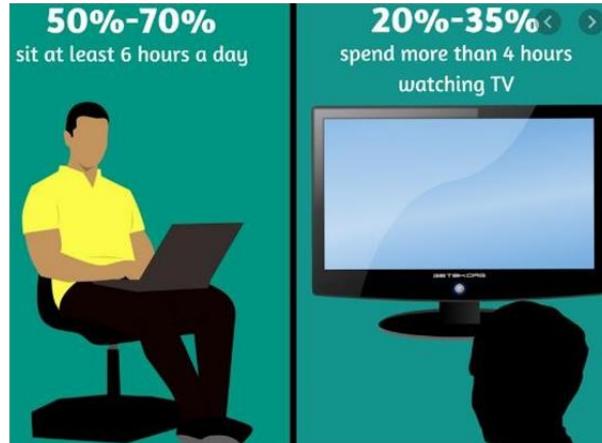
Prevention of Diseases and Maintenance of Health

3. Physical Activity Monitoring

Challenges

-Sedentary Lifestyle

- Heart problems
- High cancer risk
- Reduced muscle strength
- High blood pressure
- Improper Posture (i.e., neck pain)



Solution

- Activity monitoring (smart watch), Posture device
- Alerts and Reminders
- Habit change scores
- Social Media Motivators

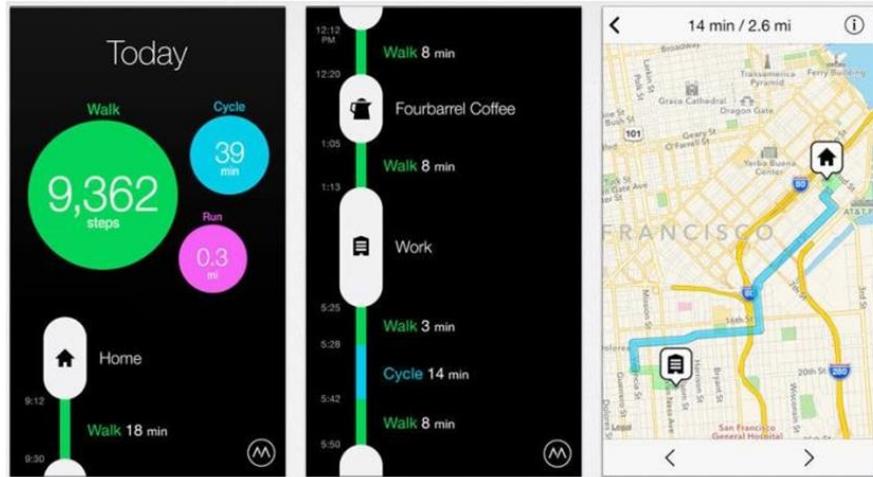


Prevention of Diseases and Maintenance of Health

3. Physical Activity and Interaction Monitoring

-Social Media Motivators

- Posting of physical activity updates on social media
- I ran 4.5 miles today #healthylife #instagood #fitness
- Check out my weightloss journey (pictures) → Likes and followers



Prevention of Diseases and Maintenance of Health

4. Mental Status Monitoring

Challenges

-Mood and Stress

- High blood pressure
- Indigestion
- Headaches and Panic attacks
- Insomnia (difficulty sleeping)
- Diabetes

Solution

-Lack of reliable wearable device

-Heart rate monitoring

-EEG monitoring

-Skin conductance

-No solution on stress reduction



Prevention of Diseases and Maintenance of Health

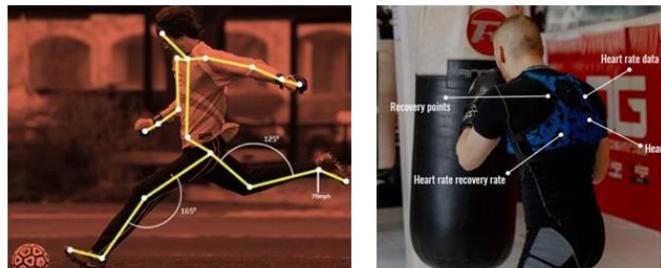
5. Sports Medicine

Challenges

- Performance evaluation of athletes
 - Stamina
 - Energy
- Injury prevention
- How to win?

Solution

- Sensors for tracking of oxygen levels, heart rate, balance, movements
- Iteratively improving performance
- Alerts for injury prevention
- Virtual Reality (VR) gears
- All foreign manufacturers



Patient Management

1. Cancer Survivors

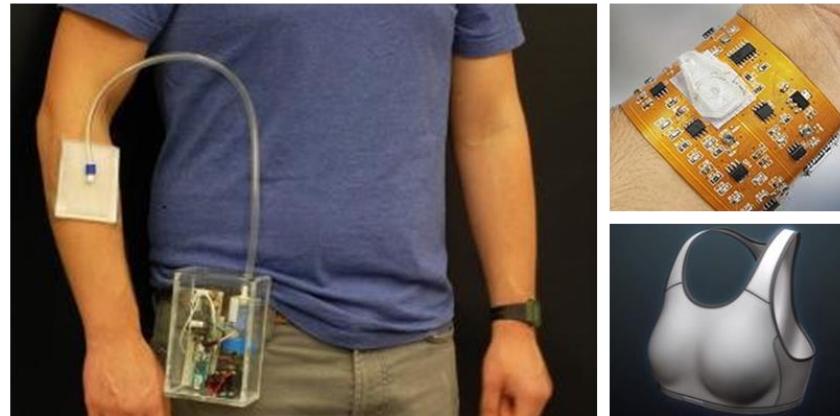
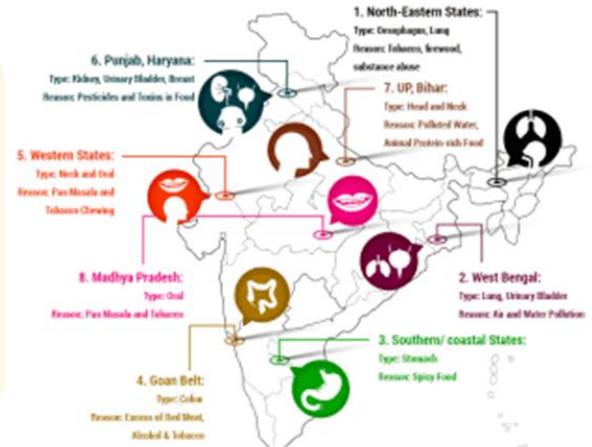
Challenges

- Low physical activity
- High obesity (>70%)
- Mental health issues

Solution

- No cancer detection
- Physical activity monitoring devices
- Smart watches
- home-based rehabilitation
- No mental health monitoring wearable

Will Cancer be the no.1 Killer in India by 2020?



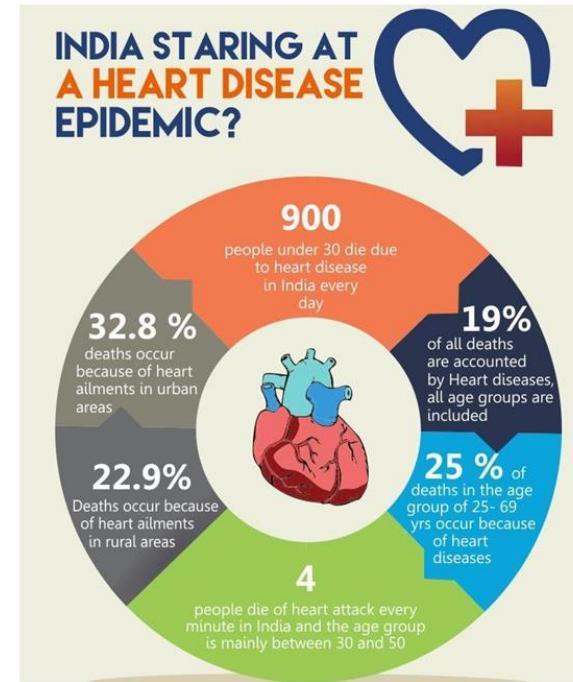
Patient Management

2. Patients with Stroke Challenges

- 33% stroke deaths in urban areas
- 900/day die daily under 30 yrs
- Increased chance with age

Solution

- Monitor activity
- Provide feedback to patients and therapist
- Alerts to hospitals
- Expensive smart watches



Patient Management

3. Patients with Brain and Spinal Cord Injuries Challenges

-Traumatic Brain Injury (TBI)

-Car accidents

-Falls

-Motor function loss due to spinal cord injury (nerve damage)

-Low recovery

Solution

-Exercises/Training to improve

-Need healthcare provider guidance

-Exoskeletons (aids movement)

-Brain signal monitoring

Just 15% of head-injury victims make it

HEADING TOWARDS DISASTER

The poor outcome of severe traumatic head injury is well known, but what happens to those who survive has not been documented.

SHOCKING RESULTS

- > Only 102 families of patients discharged from May 2010 to February 2013 could be contacted.
- > Of these, only 16 (15.7%) patients had a good outcome. They were able to gain consciousness after six months of injury.
- > 32 (31.4%) remained in a vegetative state six months after getting discharged.
- > Majority of patients, 54 (52.9%) out of 102, died within six months

POINTS TO PONDER

- > AIIMS Trauma Centre also gets 800 such cases every year.
- > Few patients survive, but those who do often need rehabilitation.
- > In absence of any social security scheme, government must arrange for rehabilitation to save lives.

DurgeshNandan.Jha
@timesgroup.com



In India, particularly in Delhi, the incidence of road mishaps is high and so is the number of people suffering from severe head injuries

Most Either Die Or Remain Unconscious After Discharge

New Delhi: Only 15% of the patients with severe head injury treated at the All India Institute of Medical Sciences (AIIMS) in an unconscious state gain consciousness even after a follow-up of six months.

This came to light after a follow-up of patients discharged from AIIMS Trauma Centre from May 2010 to February 2013.

Dr Deepak Agrawal, senior neurosurgeon, said a total of 1,232 patients were admitted to the centre during this period. The patients were called after six months to check the condition of the patients, mostly the road accident victims.

At the trauma centre, officials

said there are 52 beds in the neurosurgery department. Of these, 30 are occupied by patients suffering from severe head or spinal injury.

"Earlier, we used to say that their families do not have to suffer," said Dr Agrawal.

Those patients who are discharged in an unconscious state are often particularly difficult to manage because they are prone to bed sores, respiratory infections, inadequate nutrition, and pressure ulcers.

At the trauma centre, officials

told "My father, who is now

remained in coma for four years, was brought to us after an accident. The doctors at the private superspecialty hospital did not want to treat him and sent him home. But we could not leave him to die. We shifted him to another private hospital and he is doing well now. If there was no social security system or rehabilitation plan from the govt, it may not have saved us from poverty," said Manish Kumar, a Noida resident.

vulnerable in technology. It is possible to keep them alive and in some cases recovery of organ function has also been observed. However, we cannot guarantee that they will live together in hope of a miracle," said a senior doctor.

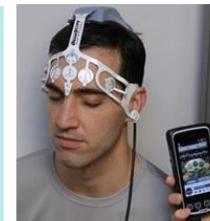
Such patients have a different story to tell. "My father, who is now

remained in coma for four

years, was brought to us after an accident. The doctors at the private superspecialty hospital did not want to treat him and sent him home. But we could not leave him to die. We shifted him to another private hospital and he is doing well now. If there was no social security system or rehabilitation plan from the govt, it may not have saved us from poverty," said Manish Kumar, a Noida resident.

NATIONAL HEALTH PORTAL
Government of India
NHP INDIA

Signs and Symptoms of Spinal Cord Injury



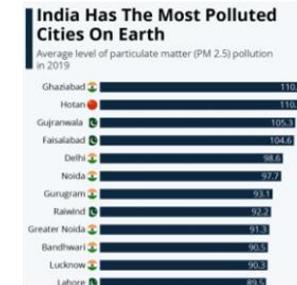
Patient Management

4. Chronic Pulmonary Patients Challenges

- Over 8% chronic obstructive pulmonary disease (COPD) patients in India
- 2nd leading cause of death
- Most polluted cities in India

Solution

- Breathable air quality monitoring
- Breathing exercises
- Improvement tracking



Disease Management-Diagnosis

1. Heart Disorders

- Low-power wearable ECG monitoring
- Textile based wearables
- Ear based BCG (blood) wearables



2. Blood Disorders

- Blood pressure monitoring
- Study of hemodynamics (blood flow)



3. Diabetes Care

- Blood glucose dynamics



4. Parkinsons (Brain) Disease

- Tremor and fixed limb signals



5. Autism (Behaviour) disorder

- Focussing and Mental Training

Key Findings from the State-of-the-art

Majorly foreign made technologies (high cost)

A few technologies were commercialized in India

Prevention of Diseases and Maintenance of Health

1. Fall Identification and Prevention
2. Weight Control and Monitoring
3. Physical Activity Monitoring
4. Mental Status Monitoring
5. Sports Medicine

Patient Management

1. Cancer Survivors
2. Patients with Stroke
3. Patients with Brain and Spinal Cord Injuries
4. Chronic Pulmonary Patients

Disease Management-Diagnosis

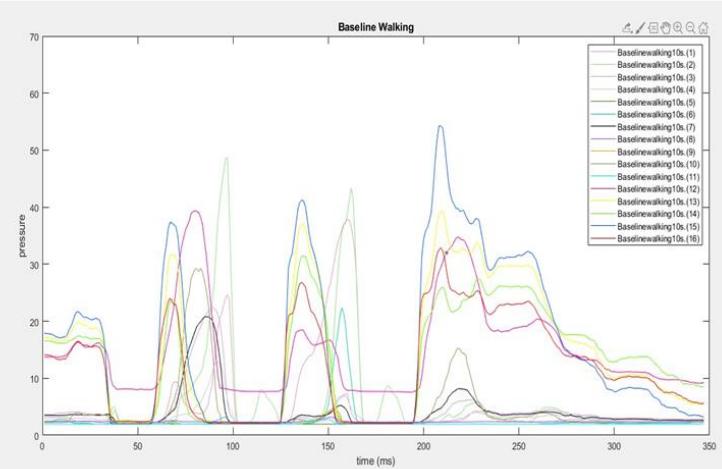
1. Heart Disorders
2. Blood Disorders
3. Diabetes Care
4. Parkinson's (Brain) Disease
5. Autism (Behavior) disorder

Some

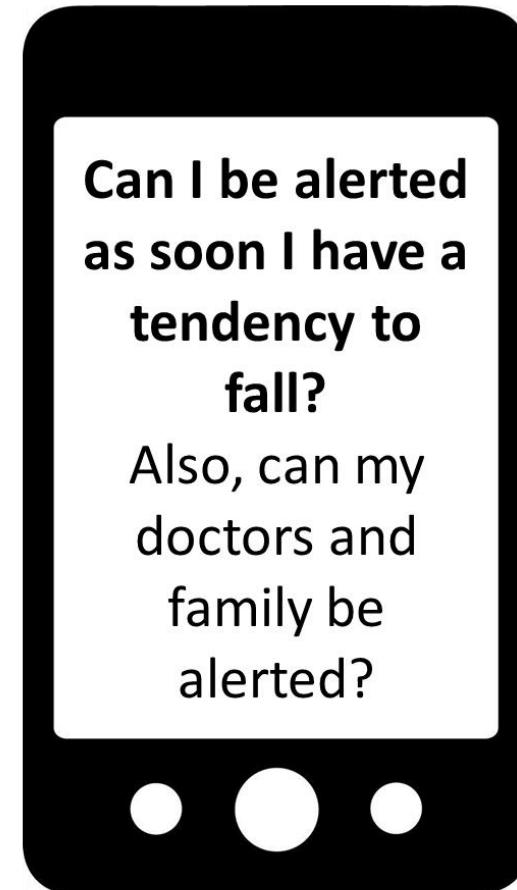
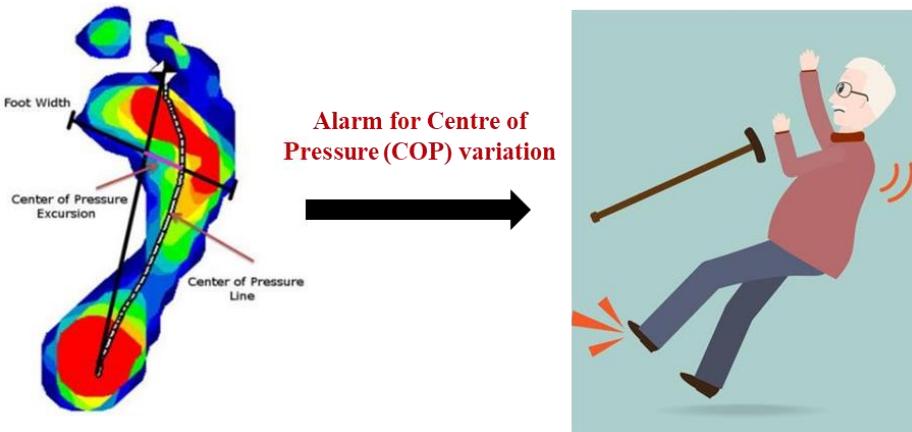
Indian Technologies

Which have been commercialized

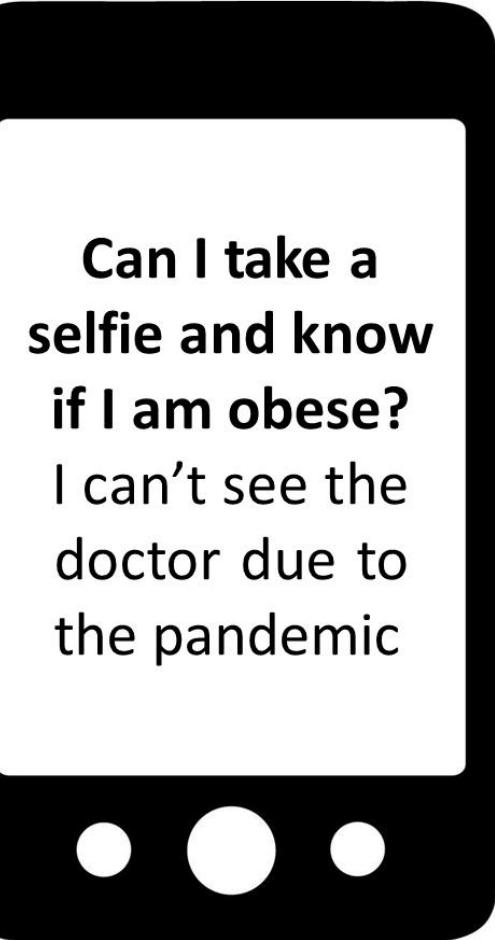
Fall Detection and Prevention



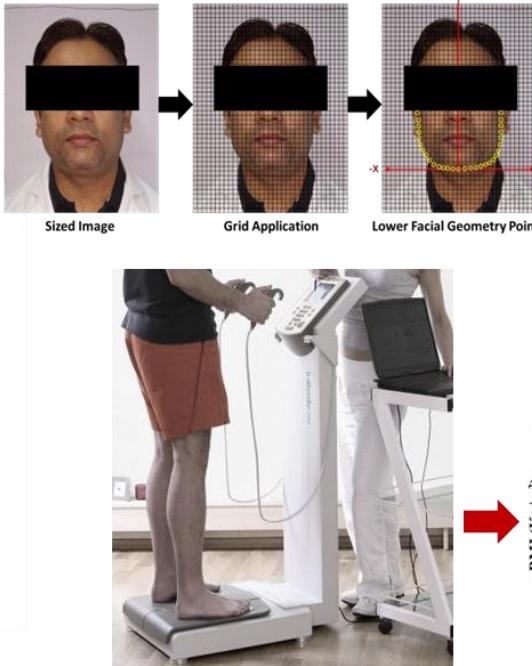
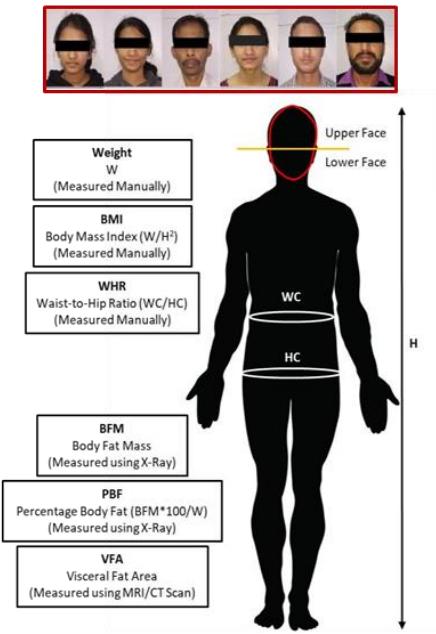
Insole to continuously monitor foot pressures



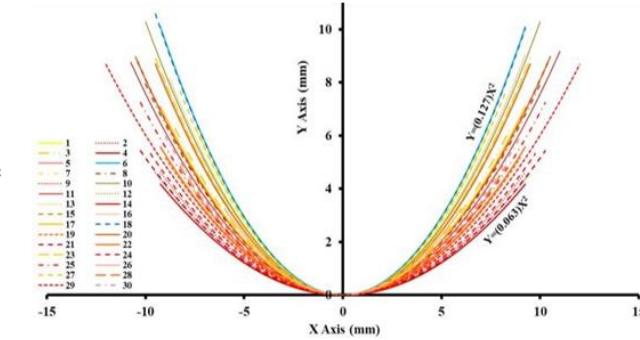
Obesity Diagnosis Using Facial Images



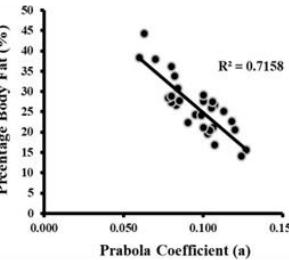
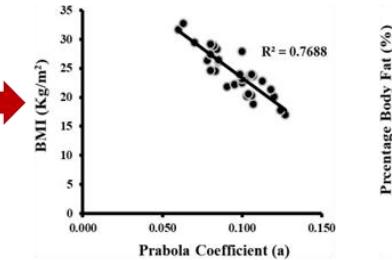
Obesity Diagnosis Using Facial Images



Anthropometric and Body Composition Measurements



Lower Facial Curve-Fitting

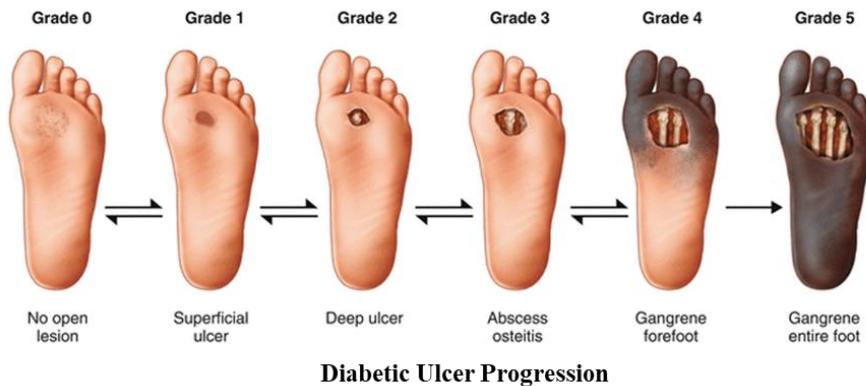


Face-Fat Correlations

**Lower facial curvature can accurately predict
BMI→Obesity**

Diabetes Care

Diabetes causing plantar neuropathy (i.e., loss of sensation underneath the foot) which needs to be monitored to prevent incidence of ulcers



**Can I be alerted
as soon I have a
chance to
develop ulcers?
I cannot feel my
foot due to
acute diabetes**

CHALLENGES in India

▪ High Cost

- Most wearable are imported and not affordable



▪ Developmental Skills

- Most wearable are in prototype stages in top research labs

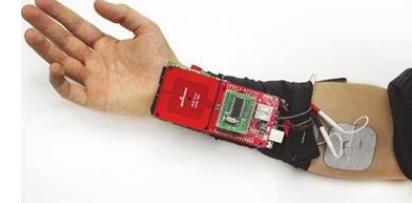
- Difficult to translate the knowledge to products

▪ User Acceptance

- Lack of awareness

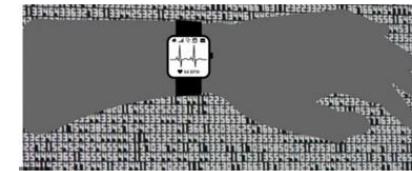
- Patients and clinicians don't want to work with them

- More difficult to sell prolong-wear wearables



▪ Security

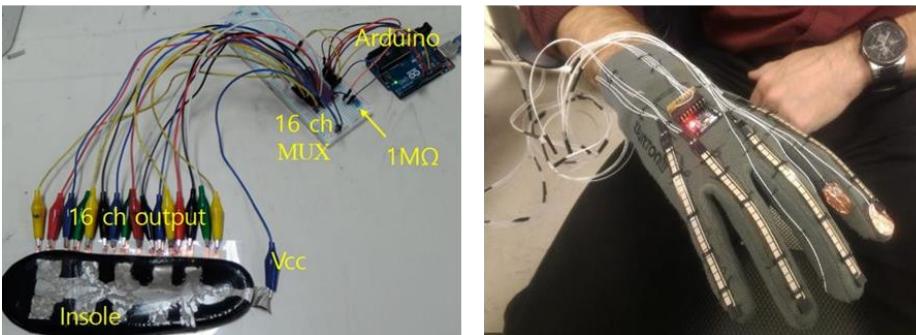
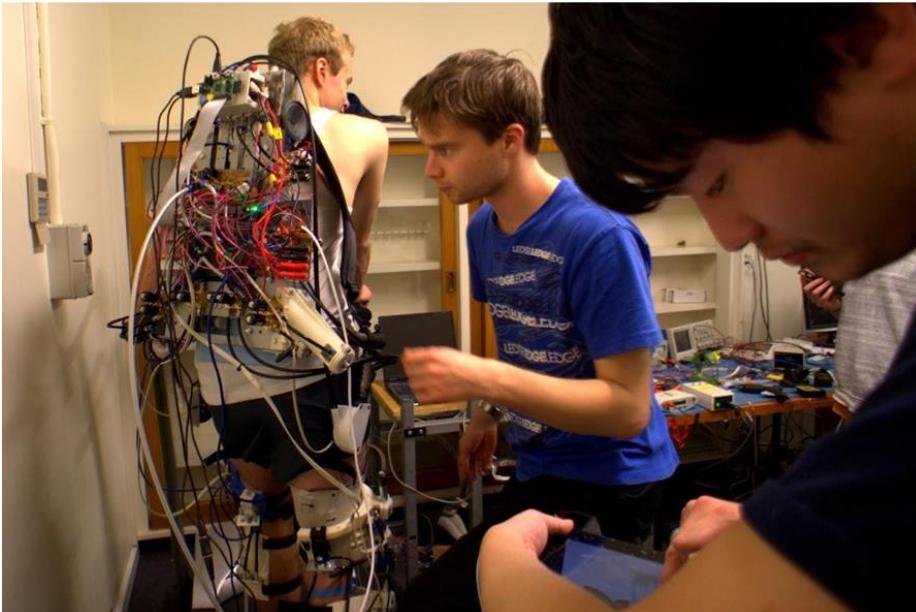
- Confidentiality and data security are major concerns



Other Indian Technologies

Which can overcome some of the challenges with wearable commercialization

Novel Soft Materials to Replace Wires



**Can wires be
reduced in
wearables
without adding
cost?**

Its
uncomfortable
to wear

Novel Soft Materials to Replace Wires

Materials like tissues and with good conduction

- Fabrication Methodology

- Soft Matrix (Two-Part Silicone)
- Short Carbon Fibers
- 30 test coupons generated



Fabrication of Conductive Surrogates

- Mechanical and Electrical Testing

- Specimen size: Length=50 mm, Width= 10 mm, Thickness=1-4 mm
- Constant strain rate (0.4 mm/s)



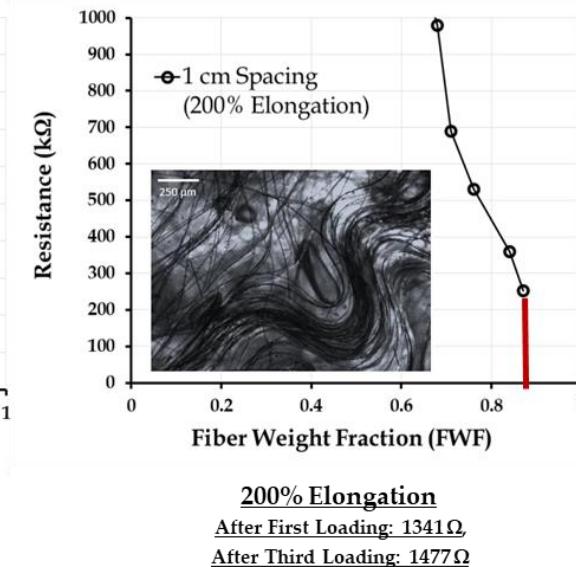
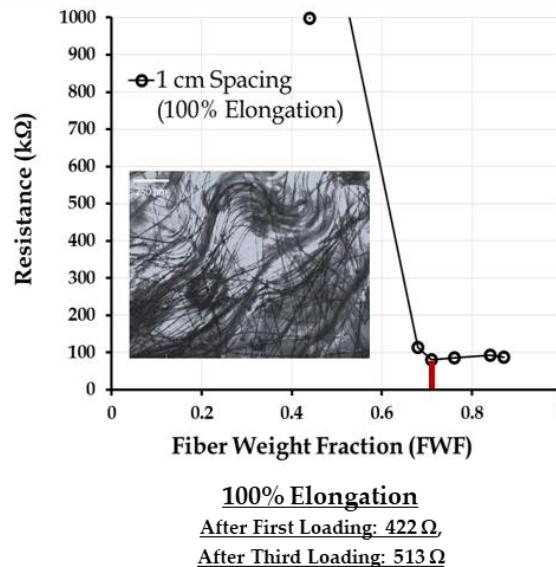
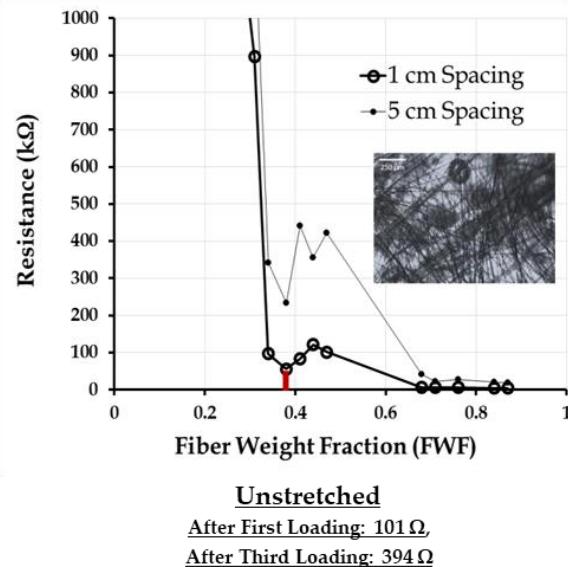
Surrogate under Tensile test and Electrical Conductivity Measurements

Novel Soft Materials to Replace Wires

Material also conducts on stretching

- Resistances at Different Fiber Weight Fractions and Stretches

- Stretching **increases** resistance
- Cyclic loading causes permanent fiber curling and increase in resistance (*till 3rd loading*)
- Higher FWF is required for high stretch applications

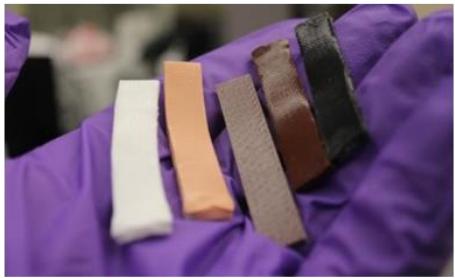


Novel Soft Materials to Replace Wires

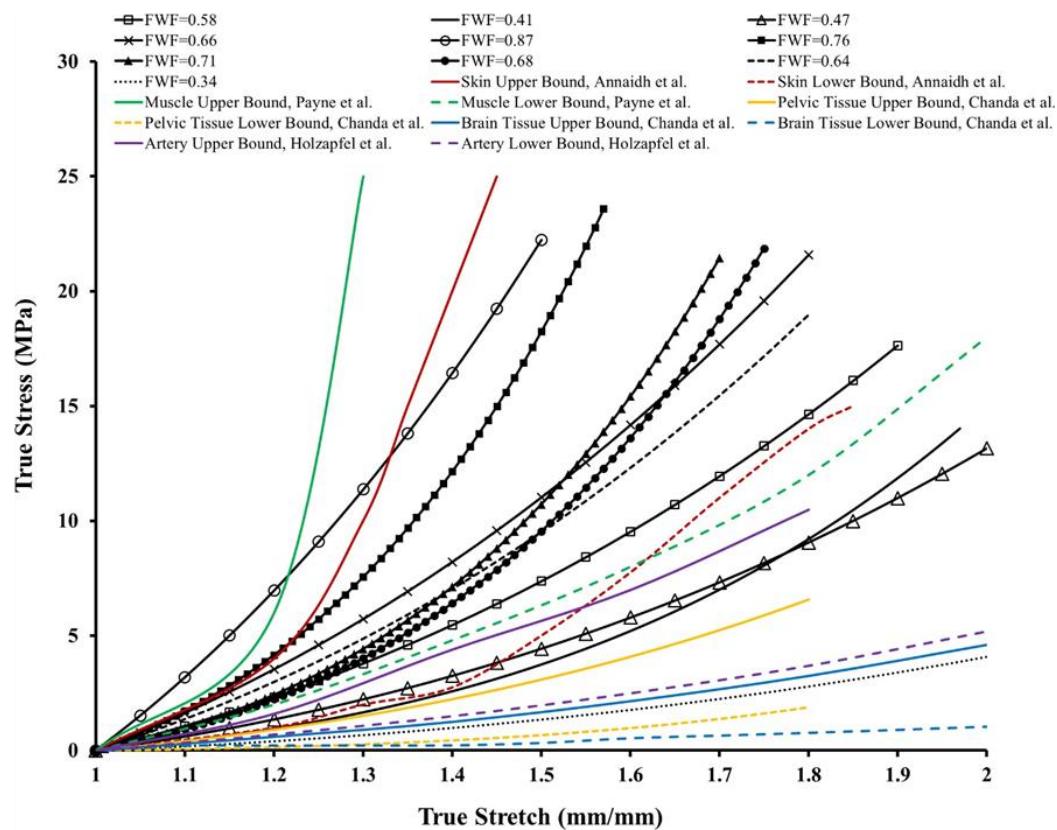
The mechanical properties are tunable

- Mechanical Properties at Different FWF's

- Three parts
 - *Two part silicone*
 - *Short carbon fibers*
- Surrogate properties made to simulate **human tissues**
- Can be masked with **colors**



Conductive Tissue Surrogates



Low Cost Sensors

flexiforce sensors

All Shopping Images Videos News More Settings Tools

About 37,400 results (0.39 seconds)

Ads · Browse flexiforce sensors

Sensors Pressure... ₹2,464.58 +... \$33.53 + tax Protocentral...	FlexiForce HT201 Forc... ₹4,099 Robu.in Free delivery	FlexiForce FlexiPot Stri... ₹1,999 Robu.in Free delivery	FlexiForce A301-25... ₹861.11 Evelta	FlexiForce A301-100... ₹849 Robu.in Free delivery
---	--	---	--	--

Rs.
10,000+
On cost of
sensors
only

Can the cost of sensors be reduced significantly?
General public will not pay for a product >1000-2000 Rs. cost

Low Cost Sensors

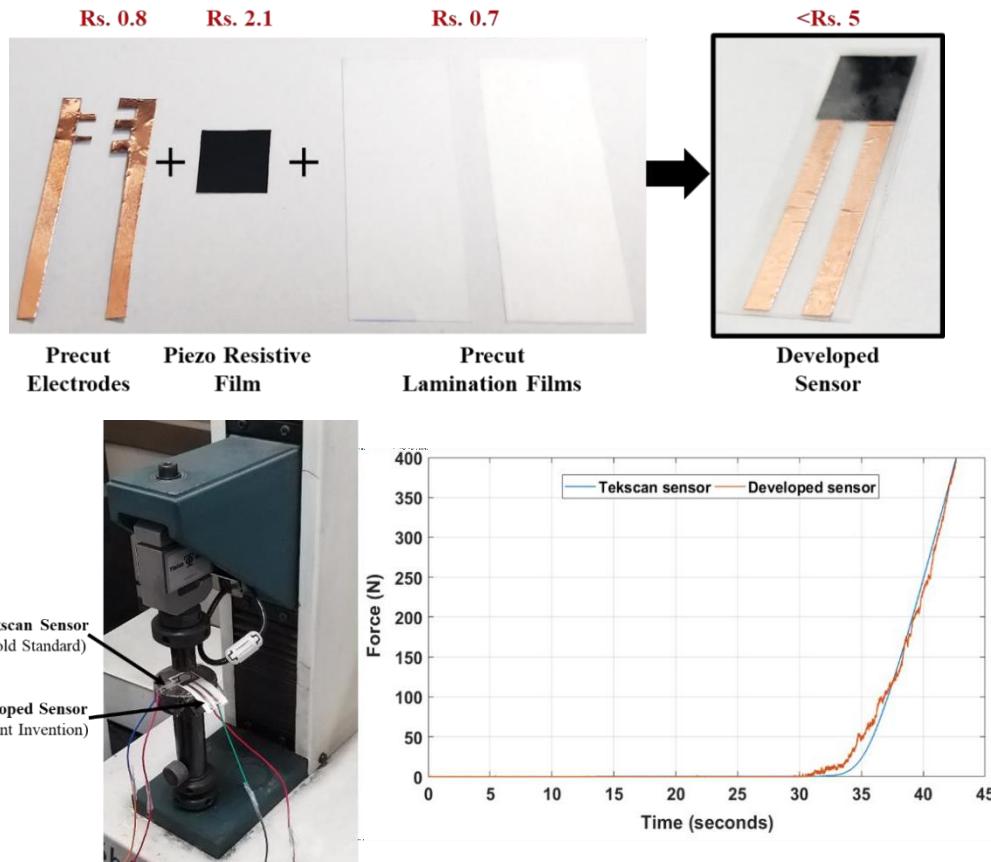
Low cost and reliable raw materials

Optimization of Sensor Design

- Three parts
 - *Precut electrodes*
 - *Piezo resistive film*
 - *Precut lamination films*
- Total cost <Rs. 5 (**170 times cost reduction**)
- Flexible and customizable sizes

Tested against commercial Tekscan sensors

- Similar force-time response
- Good repeatability
- Good reproducibility



FUTURE OPPORTUNITIES

■ Further Cost Reduction

- Cost effective designs (3D printing)
- Low cost electronics



■ Start-ups

- Develop innovative wearables in India
- Partner with research universities (IITs/NITs/Govt. Institutes)



■ User Friendly

- Promote awareness
- Develop easy-to-use products only
- Understand customer pains/needs



■ Artificial Intelligence (AI)

- Ethically collect data for better clinical predictions

