
The challenges in harnessing wearables, machine learning and big data analytics for better care

Eran Ofir, CEO & co-founder

November, 2018
My plan for the next 30 min

- **Market:** Let’s start with the Why
- **Product:** Example of Real life platform integrating Big Data, ML, AI, IoT, software, hardware and firmware
- **Technical:** Challenges developers faced upon building it
- **Bonus:** Tips for the bumpy road
- **Q&MA:** Questions and maybe Answers
• Healthcare spending continues to represent an excessively large part of the US economy
• The push for innovation in the space is getting more intense
• Tech companies charge deeper into healthcare
• Telecom companies lose out to Amazon, Google and Apple in med tech telemedicine race

Amazon announced it would form an independent healthcare company with Berkshire Hathaway and JPMorgan Chase

Verily, a life-sciences unit of Google's parent company Alphabet, is reportedly seeking to break into a segment of health insurance

Apple is working to build the Apple Watch into a medical-monitoring device and establish its Healthkit as an industry-wide standard for health-data storage
A growing demand for connected healthcare

- The potential of delivering solutions such as remote patient monitoring, patient communication and engagement tools is HUGE
- More than 115 million Americans will require caregiving assistance
- Telecommunication services have long been the catalyst for industries looking to achieve efficiencies and collaboration across business processes
Connecting millions to the emerging Digital Health

**Vodafone mHealth**

**Services:**
Integrating patient devices with the company’s hardware, software and managed connectivity.

**Solutions:**
Remote monitoring, independent living, clinical trials, supply chain.

**Health Solutions:**
Accessing and collaborating on patient records, integrating health and social care, simplifying communications and networks, secure data and communications, Casebook 3 tablet for healthcare sector.

**AT&T Healthcare:**
Helping healthcare organizations transform the continuum of care, from the waiting room, to the operating room, to the living room, with technologies, including networking, mobility, cybersecurity, IoT.

**Orange Healthcare:**
Platforms that support vulnerable and dependent people, ageing population and medical monitoring. Hosting, exploiting and transmitting medical data. Supporting the digital transformation of the healthcare industry.
Connecting millions to the emerging Digital Health

**Deutsche Telekom Healthcare Solutions:**
Hospital information systems, healthcare content management, interoperability, telemedicine, smart home emergency call system, intelligent assistance system intelligent care bed, telematics.

**BT Group Health Solutions:**
Creating digitally connected and collaborative workplaces, integrating health and social care systems, predictive analytics, delivering integrated care plans and pathways, protecting sensitive information with BT Security.

**Swisscom E-Health:**
Swisscom runs a digital ecosystem for the Swiss health sector which is constantly being expanded and integrating new players. They connect up service providers, health insurance companies and private citizens and offer them innovative products and solutions.
Digital Health is the intersection of:

Wearables, Internet of Things, mobile health platforms and artificial intelligence are quickly expanding into all areas of patient monitoring and disease management.
What is Integrated Digital Healthcare Program?

Building a new *Digital Healthcare* ecosystem of partners

![Diagram showing the integration of users, wearables, software platform, IoT home and mobile devices, telecom operator, and providers.](image)
Introducing Somatix

A provider of real-time wearable-assisted gesture detection

Remote Patient Monitoring (RPM) platform

for cost-effective healthcare and wellbeing enhancement

Utilizing sensors built into smartwatches and smartbands

Completely passive monitoring – no user effort required

Precise recognition of a range of physical and emotional states

Behavioral change via personalized intervention

"Somatix takes the activity tracker from an athletic option to a clinical imperative”  
John Nosta
Automated precise recognition of a range of gestures

Tooth brushing, Eating, Drinking (cold/hot), Smoking

...walking, sleeping, shaving, taking medication

Leveraging existing sensors in commercial off-the-shelf wearables

Accelerometer, Gyroscope, Heart rate, GPS, Barometer, Electrodermal activity, Skin temperature
“The motion detecting sensors in these devices generate an enormous amount of data, and if analyzed correctly, this haystack of information can yield all sorts of actionable insight” Alfred Poor
Redefining remote monitoring for better healthcare

1. Real-time, device agnostic, automated gesture detection software platform
2. Personalized insights generated by adaptive Machine Learning and Big Data analytics
3. Immediate awareness of changes via alerts, reminders and notifications

Optional use cases – a differentiated approach

- Smoking cessation, drug & alcohol rehabilitation
- Elderly Care & Hospital discharged patient continuity of care
- Cognitive & motor neurological diseases
Automated precise recognition of a range of gestures

- Tooth brushing
- Eating
- Drinking (cold/hot)
- Smoking

Walking, sleeping, shaving, taking medication

Leveraging sensors in commercial off-the-shelf wearables

- Accelerometer
- Gyroscope
- Heartrate
- GPS
- Barometer
- Electrodermal activity
- Skin temperature
SafeBeing: Providing complete peace of mind

Requires no sensors or cameras to be installed in the users’ environment

Passive remote monitoring of elderly, discharged and chronic patients’ ADLs (Activities of Daily Living), to continuously detect their physical state

- Falls
- Mobility
- Sleeping habit
- Neurological malfunctioning
- Missed meals
- Low liquid consumption
- Smoking

Delivers information on a range of behavior indicators, real-time alerts and notifications providing caregivers with immediate awareness of change in behavior or other abnormality
SafeBeing high level architecture

Somatix Real-time Gesture Detection Platform

Security & Privacy
- Insights
- Alerts
- Reminders
- Predictions
- Patterns
- Stats & Reports

3rd Party Integration Layer

Caregiver dashboard
- Patient activation and management
- Stats/reports
- Alerts/notification/communication

User/family mobile app
- Alerts/reminders
- Stats/reports
- Communication

Weather
Heartbeat
Location
EHR

Caregiver
Mobile app

Patient
Wearables’ Sensors
A software platform for healthcare and behavioral monitoring
- Analyzes data from wearable, mobile devices, sensors, etc.
- Detection and monitoring of user gestures in real-time
- Delivery of relevant and personalized information in a timely manner

See, e.g. US 2017/0262064 and WO/2016/100368 (Methods and Systems for Monitoring and Influencing Gesture-based Behaviors)
On-going academic validation

<table>
<thead>
<tr>
<th>Published:</th>
<th>Existing studies at:</th>
<th>Grants work:</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAMBRIDGE UNIVERSITY PRESS</td>
<td><strong>Yale</strong></td>
<td>NIH</td>
</tr>
<tr>
<td>DALHOUSIE UNIVERSITY</td>
<td>Using ‘Smart’ Technology to Aid in Cigarette Smoking Cessation: Examining an Innovative Way to Monitor and Improve Quit Attempt Outcomes</td>
<td>NIDA</td>
</tr>
<tr>
<td>OXFORD UNIVERSITY PRESS</td>
<td><strong>Penn</strong></td>
<td>NSF</td>
</tr>
<tr>
<td>TEL AVIV UNIVERSITY</td>
<td><strong>Mount Sinai</strong></td>
<td>BIRD (Israel-U.S. Binational Industrial Research and Development Foundation)</td>
</tr>
</tbody>
</table>

Effect of Real-Time Monitoring and Notification of Smoking Episodes on Smoking Reduction: A Pilot Study of a Novel Smoking Cessation App

© Somatix 2018
Where do we use ML? (examples)

• Gestures detection in real-time
  - For complex gesture detection (e.g. smoking, drinking, eating, medication, etc...) we use state-of-the-art machine learning boosting algorithms
  - Due to the fact that our machine learning algorithms typically run on weak (low memory, low CPU, low battery) IoT systems, we chose the boosting algorithms that are suitable for these systems
  - For less complex activities (e.g. falling and sleeping) we use typical linear classifiers

• Dynamic level detection
  - We measure this based on accelerometer signals (variance)
  - We use statistical tests to see if dynamic level is significantly different from required pre-configured level

• Activity level detection
  - We measure activity level based on accelerometer step detector
  - We use statistical tests to see if activity level is significantly different from required pre-configured level

• Converting CBT (Cognitive Behavior Therapy) and ACT (Acceptance and Commitment Therapy) into algorithms
  - SERFTM behavior modification engine
Where do we use AI? (examples)

• In our internal jargon, ML is being used for base-detection, and AI is being used for insights

• We derive insights from the large data sets of information we continuously collect
  • We predict when and where a typical action will occur using multi-dimensional clustering algorithms (e.g. when will a person smoke his next cigarette)
  • We detect changes in patterns using anomaly detection algorithms and statistical tests (e.g. wandering alerts)
  • We identify when a change in pattern becomes a trend (an elderly becomes less active over a span of weeks) using anomaly detection algorithms and statistical tests
  • We detect a user’s significant locations (aka POI) based on clustering algorithms
  • We detect when a user switches the smartband hand (e.g. from right to left) by employing a simple linear classifier with meticulously chosen features
SmokeBeat dashboard: Statistics, patterns, location and more
SmokeBeat dashboard: Comparative treatments efficacy
SafeBeing dashboard: presenting Activities of Daily Living
• Platform backend infrastructure was built with Java – Spring
  • Chosen as it is proven enterprise technologies for robustness and scale
  • Using Spring framework including Spring Boot, Spring Core, Spring Security, Spring Data-JPA and Spring MVC

• Platform deployed on Amazon AWS servers
  • Computing - EC2 class
  • Storage - S3 class
  • Database - RDS / MYSQL
  • Networking - APIGateway, Route53
  • User management - Cognito
The How (2)

- **Business logic:**
  - Security service – using AWS Cognito platform to manage the users’ credentials and authentication
  - Notification services – using standard third-party platforms Firebase, Twilio (for SMS notification), and AWS Simple Notification Services (SNS, for sending emails)
  - Main entities management – user, sessions (smoking episodes), location, physician, clinic, etc
  - Mobile service – various APIs to interact with the mobile applications
  - Clinic Service – various APIs to interact with the dashboard web application
The How - Platform architecture
The How – Events High Level Architecture

Recipients
- Admin
- User
- Dashboard

Backend
- Alerts audit
- Alerts rules
- Sessions heartbeat location
- Delivery manager
- Alerts engine

Admin → admin → Notification, in app → dashboard
Challenges (examples)

- Classifiers run on low power, low CPU and low memory IoT devices
  - Low power – use suitable classifiers that don’t need non-linear functions
  - Low memory
    - ROM – static variables and the code itself (surprising for us to have shortage there)
    - RAM – dynamic variables
  - System architecture is complex to support this
    - We use a combination of weak and strong classifiers in cascade to reap the advantages of both
  - Develop proprietary C implementation for boosting algorithms that are very efficient (power, CPU, memory)

- Immaturity of wearables operating systems
  - Variety – Android, iOS, Tizen
  - Frequent Crashes
  - Frequent changes to API
  - A system that serves many applications with different requirements
    - Sensor sampling rates change frequently, some samples are lost, sensor might be periodically reset
  - Functionality is not as at spec – sensors, BLE,
Challenges (examples)

• Real-time is needed, on large data sets
• Power consumption of algorithms running on wearables
  • Accessing the sensors gradually and not all in once
  • Turning off CPU when not in use
  • Collecting and sending data in batches
  • Using families of low-power classifiers
A very positive market endorsement

<table>
<thead>
<tr>
<th>Awarded by:</th>
<th>As featured in:</th>
<th>Selected by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun 2018: Winner of the RED HERRING TOP 100 North America award</td>
<td>WIRED</td>
<td>SAP Certified</td>
</tr>
<tr>
<td></td>
<td>MedCity News</td>
<td>TADA Consulting Services</td>
</tr>
<tr>
<td></td>
<td>Inc.</td>
<td>TechRadar</td>
</tr>
<tr>
<td></td>
<td>eWEEK</td>
<td>WAREABLE</td>
</tr>
<tr>
<td></td>
<td>CHILMARK RESEARCH</td>
<td>Somatix</td>
</tr>
</tbody>
</table>
THANK YOU!

For further information, please contact me at: erano@somatix.com