EECS 507: Introduction to Embedded Systems Research Applications: Wearables

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Outline

Action items I

19 Sep: A. Sangiovanni-Vincentelli, W. Damm, and R. Passerone, "Taming Dr. Frankenstein: Contract-based design for cyber-physical systems," *European Journal of Control*, vol. 18, no. 3, pp. 217–238, 2012.

24 Sep: L. Zhang, B. Tiwana, Z. Qian, Z. Wang, R. P. Dick, Z. M. Mao, and L. Yang, "Accurate online power estimation and automatic battery behavior based power model generation for smartphones," in *Proc. Int. Conf. Hardware/Software Codesign and System Synthesis*, Oct. 2010, pp. 105–114.

26 Sep: J. Polastre, R. Szewczyk, A. Mainwaring, D. Culler, and J. Anderson, "Analysis of wireless sensor networks for habitat monitoring," in *Wireless Sensor Networks*, C. S. Raghavendra, K. M. Sivalingam, and T. Znati, Eds. Springer US, 2004, ch. 18, pp. 399–423.

26 Sep: Final project proposals.

Action items II

1 Oct: E. Ronen, A. Shamir, A.-O. Weingarten, and C. O'Flynn, "IoT goes nuclear: Creating a ZigBee chain reaction," in *Proc. Symp. on Security and Privacy*, May 2017.

3 Oct: K. Mekki, E. Bajic, F. Chaxel, and F. Meyer, "A comparative study of LPWAN technologies for large-scale IoT deployment," *Elsevier ICT Express*, vol. 5, no. 1, pp. 1–7, Mar. 2019.

8 Oct: D. Yeke, M. Ibrahim, G. S. Tuncay, H. Farrukh, A. Imran, A. Bianchi, and Z. B. Celik, "Wear's my data? understanding the cross-device runtime permission model in wearables," in *Symp. on Security and Privacy*, May 2024, pp. 2404–2401.

10 Oct: Midterm exam.

Outline

Properties

- Worn on body.
- Unobtrusive.
- Measures and displays data from body or environment.
- Many niches, with activity monitoring and sports important.

Market and history I

2000s: Flashing clothing digital "art" exhibits.

2003–: Garmin Forerunner sports watch.

2004–: Suunto sports watch.

2009–: Fitbit activity tracker.

2010–2017: Recon HUD. Sold to Intel in 2015. 

2012–: Misfit Shine activity tracker (Fossil Group at $260M in 2015).

2013–2016: Pebble smart watch. 

2013–2015: Bia sports watch. 

2014–2015: Google Glass. "Enterprise edition" promised in the future. 

Market and history II

2015–: Apple smart watch.

2011–2017: Jawbone activity tracker. ☠

2024–: Humane AI Pin.

2024–: Rabbit R1.

Xiaomi also a major player.

Many, many more. ☠, ☠, ☠

Recon

Misfit Shine

Bia Sportswatch

Stryd

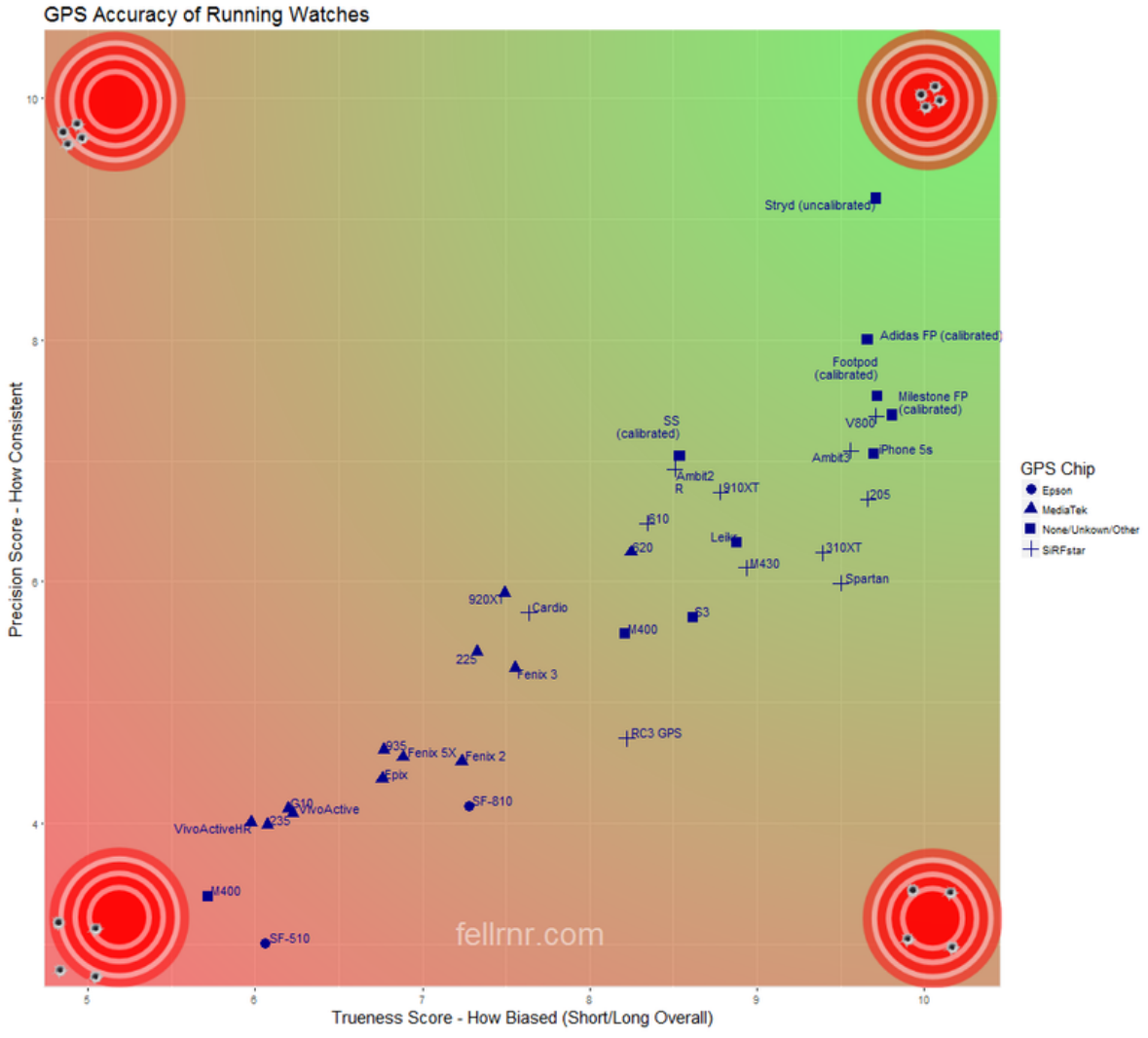
2015–: wearable power meter for runners and triathletes.

Focused on specific training and racing use cases.

Broad ecosystem support.

Focus on product performance.

GPS vs. IMU


GPS Accuracy of Running Watches
Precision Score - How Consistent
Trueness Score - How Biased (Short/Long Overall)
fellrnr.com
Stryd (uncalibrated)
Adidas FP (calibrated)
Footpod (calibrated)
Milestone FP (calibrated)
SS (calibrated)
V800
Ambit3
iPhone 5s
Ambit2 R
910XT
205
310XT
M430
Spartan
920XT
Cardio
M400
225
Fenix 3
RC3 GPS
935
Fenix 5X
Fenix 2
Epix
SF-810
VivoActive
VivoActiveHR
235
M400
SF-510
GPS Chip
Epson
MediaTek
None/Unkown/Other
SiRFstar

Humane AI Pin and Rabbit R1

Humane: Seeing, talking, hand-projecting AI Pin.

Rabbit: AI assistant in a box with audio, camera, and screen.

Brutal reviews.

Wearable location tracking security implications

Security

Strava is a military security nightmare as US base locations are leaked by fitness fanatics

By tracking user's exercise habits, Strava has unwittingly become a major security breach for the US military

Vaughn Highfield
@starfox118

29 Jan 2018

Strava, the running and cycling fitness tracking app, has unwittingly revealed some of the US

Wearables: a target-rich environment

- Detailed training and performance data.
- Location tracking.
- Control of drug delivery.
- Heart stimulation, etc.

Connectivity

- Bluetooth LE / SMART.
- USB.
- ANT+.

Common sensors

- IMUs.
- (Optical) heart rate.
- Temperature.
- Barometers.
- Blood glucose.
- GSR.
- Many more.

Design considerations

Determine most important attributes for specific application.

Optimize these (they will almost certainly conflict).

Focus on capabilities not specifications: Apple not Samsung.

Startups vs. established companies

Startups can adapt rapidly

- Founders are personally doing market research and understand technology.
- No fifedoms.
- Limited disagreement on whether the company is searching or "in the goldmine".
- Most employees treat the company as if they own it.

Established companies

- Generally have more money and development resources.
- Generally have some competent people in relevant areas, so less likely to make naïve mistakes.
- Less prone to personality conflicts destroying the company.

Future

- Killer app.
- Generality vs. stickiness.
- Medical.
- Conductive fabric.
- CNT probes.
- Understanding application in detail.