Tactile Internet and Edge Computing: Emerging Technologies for Mobile Health

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IEEE ICC 2017, Paris
Remote surgery technology a boost for Lebanon doctors

Doctor uses iPad to conduct remote surgery in Gaza

By Susie East, for CNN

Updated 1018 GMT (1818 HKT) May 26, 2016

"I see on my screen the surgical feed that is being captured by the camera in Gaza and I'm able to draw on my screen the incision that needs to be done," says Dr. Ghassan Abu-Sitta, Head of Plastic Surgery at the American University of Beirut Medical Center.
Pictured is the world's first pneumatically controlled endoscope robot which can assist in low invasive surgery. A sensor in the surgeon's cap gives them control of the camera's movement while operating.

Surgical environment includes a stable field of vision as anticipated by the surgeon.

**Conventional**
- Surgeon transmits instructions verbally to the scopist.

**EMARO-based**
- Gyroscope
- Surgeon's head movements are transmitted as instructions to the robot.

- Robot arm holds the endoscope
- Vision field is controlled by head tracking
Photos: Could this technology be the future of surgery?

Here the surgeon (left) controls the da Vinci robot to remove a tumor in a patient. The robot has a magnified 3D vision system which can give the surgeon a clearer view of the operation.

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Can a surgeon control the da Vinci robot from outside the operation room?
Can a gastroenterologist in Paris perform remote endoscopy for a patient in Beirut?
• Ultra low e2e delays (??? ms)
• Ultra high reliability (??? %)
• High quality broadband (??? Mbps)
• Positioning accuracy (??? mm)
• Security and privacy, ...

Not yet!

10,000 Km $\rightarrow$ 33 ms
Plan to define eHealth use case for the Tactile Internet standard.

If you are interested to contribute, please email: zd03@aub.edu.lb
Mobile health for neurological applications

Wearable sensing

- EEG sensor
- ECG sensor
- Blood pressure sensor
- Hydration sensor
- Motion sensor

Wearable sensing

Mobile computing

- Dynamic on-demand sensing
- Remote diagnosis
- Predictive analytics
- Emergency notifications

Cloud analytics

Wearable sensing

Mobile computing

Cloud analytics

1. Wearable sensing
2. Mobile computing
3. Cloud analytics

Mobile health for neurological applications

- Remote diagnosis
- Predictive analytics
- Emergency notifications

Dynamic on-demand sensing

Cellular

WIFI

WIFI

NeuroPro

American University of Beirut
More than 50 million people worldwide are affected by epilepsy.

Risk of sudden death among epilepsy patients is 24x greater...

... and the mortality rate among people with epilepsy is 2-3x higher than the general population.

30% of the time, epilepsy patients do not respond to treatment.

75% of affected people in developing countries do not get treatment.

For epilepsy sufferers, one of the most frustrating aspects is not knowing when a seizure will occur...

What is Epilepsy?

The epilepsies are a spectrum of brain disorders ranging from severe, life-threatening and disabling, to ones that are much more benign. In epilepsy, the normal pattern of neuronal activity becomes disturbed, causing strange sensations, emotions, and behavior or sometimes convulsions, muscle spasms, and loss of consciousness. The epilepsies have many possible causes and there are several types of seizures.

NIH National Institute of Neurological Disorders and Stroke
DSI – 24: Research grade wireless EEG headset
Designed for rapid application of 21 sensors at locations

Properties:
• Self-donned and ready to record EEG in under 5 minutes
• Portable design suitable for light ambulation in office or lab environment
• 21 sensors positioned according to the 10-20 International System
• Continuous impedance monitoring
• Bluetooth wireless transmission with sampling at 300Hz

Possible Usages:
Adapting the prediction process to noisy signals through identifying specific and defined Artifacts from lab-acquired EEG data: movement, blinking, tension, facial expressions, interferences, etc....
How much data does a mobile EEG headset generate per hour?

**Data volume (MB) vs. recording setup**

- **1 min window, 1 channel, 256 Hz**: 0.03 MB
- **1 min, 29 channels, 256 Hz**: 0.89 MB
- **1 hr window, 1 channel, 256 Hz**: 1.84 MB
- **1 hr, 29 channels, 256 Hz**: 54 MB
- **1 hr, 29 channels, 512 Hz**: 107 MB

The data volume increases significantly with longer recording periods and more channels.
• When to sense and collect EEG data, and for how long?
• Where to process this data?
• How to process this data?
• What are delay, reliability, processing, & energy requirements?
How to process?

**Epilepsy prediction:** predict seizure onset seconds to minutes before

- **Use case:** Real time notification via mobile app
- **Requirements:** Very challenging to predict, but more complex processing can be handled in the cloud
Epilepsy detection: detect seizure onset as soon as it happens

- **Use case:** Automated deep brain stimulation
- **Requirements:** Relatively easy to detect, but all processing should be at the edge, using one or multiple cooperative devices
How to detect & predict epileptic seizures?

- Real time
- Self-learning
- Multi-dimensional
- Patient-centric
- Robust
N-gram based feature extraction for EEG signals

Controlling Parameters:
- Window size
- Interval Length
- Pattern Length
- Offset

*Anomalies ratios are high before the seizure-onset

Seizure onset

30 sec intervals

Amp Patterns: [2 6 5 8 1 2 6 3 2 2 2 1 1 2 4 1 2 6 2 2 2 1 1 2 4 1 2 3 4 5 6 7 1 2 3 4 5 2 0 0 0 2 3 4 5 6 2 3 4 5 2 2 2 1 1 2 4 0 1 2 3 4 5 6 7 8 9 1 2 2 1 4]

Significant pattern count per sub-interval: [ C1 | C2 | C3 | C4 | .......... | Ck ]

Anomalies Ratios per sub-interval: [ A1 | A2 | A3 | A4 | .......... | Ak ]
Epilepsy prediction: Sample results...

- **Accuracy** = \(\frac{\sum TP + \sum TN}{\sum TP + \sum TN + \sum FP + \sum FN}\)
- **Sensitivity** = \(\frac{\sum TP}{\sum TP + \sum FN}\)
- **False Alarm** = \(\frac{\sum TN}{\sum TN + \sum FP}\)