EM Camera
Malihe Zarre Doorghbadi
PhD student, Nanoelectronics Group
Department of informatics

Microwave Imaging

- Microwave imaging gets a lot of information about what the object is made of and what is inside it
- Microwave imaging is safer than the traditional X-rays
- Microwave imaging is low cost
Applications

• Medical diagnosis (e.g. breast cancer detection)
  The EM waves are sensitive to
  – type of tissue
  – several physical and physiological factors like
    • temperature, solute concentration, blood flow rate

• Nondestructive detecting of the internal damage in concrete structures

• Security screening at transportation terminals (railways, airports, bus stations and subways)
  • ...

EM Camera for Detecting the Damage at Concrete

• Microwave source (frequency range from 7 GHz to 13 GHz)
• Transmitting antenna radiates an electromagnetic incident field into the concrete
• The incident field excites the rebars inducing a surface current on it. This current generates a microwave scattered field
• The backscattered field is measured with a sensor array placed in the aperture of a receiving antenna

[K. Belkebiri et al., 24th European Microwave Conference, 1994]
UWB Camera is:

- UWB transmitting/receiving antenna arrays
- Based on the time delay & sum beam forming

UWB Beamforming

- Delay & sum beamforming
  - $s(t)$ is the impulse signal
  - $\phi_0$ is the steering angle
  - $h_n$ weighting coefficient
  - $d$ is antenna spacing
  - $c$ is propagation speed

\[
\tau_{\phi} = \frac{d}{c} \sin(\phi)
\]
\[
\tau_{\phi_0} = \frac{d}{c} \sin(\phi_0)
\]
\[
y_n(t) = s(t + n \tau_{\phi})
\]
\[
y(\phi, \phi_0, t) = \frac{1}{\sum h_n} \sum_{n=0}^{N-1} h_n s(t + n(\tau_{\phi} - \tau_{\phi_0}))
\]

• 7 elements linear array
• $h_n = 1 \quad n=0...6$
• Steering angle=$0^\circ$
• $d = \lambda/2 \quad (\lambda=c.T \text{ and } T \text{ is the duration time of impulse signal})$
Steering angle = 40°

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Steering angle = 40°

d = λ/2

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d = λ/2
UWB Beampattern

- Pulses do not exist simultaneously: no interference and spatial aliasing: Lack of grating lobes
  - Antenna spacing larger than $\lambda/2$
    » better resolution & beam focusing


[Images of beampatterns for narrow band and UWB, showing the effect of antenna spacing on beam focusing]

- The larger antenna spacing, the better beam focusing
Receiving UWB Camera based on delay & sum beamforming with 2×2 antennas and 7×7 simultaneous active pixels

[T. Chu and H. Hashemi, ISSCC 2008]

Future works

- Near field UWB beamforming
- Transmitting arrays
- Irregular or sparse arrays
- UWB antenna
- ...

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References


Thank you!
Steering angle = 40°
\[ d = \frac{\lambda}{2} \]