Telemedicine  Erik Borälv
Today...

- **Telemedicine**
  - What it is
  - What do we as IT-experts need to know
  - A case

- **Decision support**
  - A little about what it is
  - A case, example
"Telemedicine"

- Once a big hype, maybe not anymore
  - Everything is *tele*- these days
  - Medicine used to be very local
- It means some kind of medical practice at a distance, remote medical procedures or examinations.
  - real time (synchronous)
  - store-and-forward (asynchronous)
History

- Wilhelm Einthoven (Nobel Price 1924, ECG) did consultations over phone lines in 1906.
- In 1920 there were applications for sailors, sometimes said to be the start of telemedicine.
  - Sahlgrenska in Gothenburg gave advice over the radio in case of emergencies.
- X-Ray over phone and early satellite during the 1950s in the states.
Basic telemedicine

- Phone
- Phone + TV (video conference)
  - Education
  - Emergency, live broadcast from trauma rooms
  - Consultation with patient present, a sort of interactive decision support
Why telemedicine?

- War
  - Many injuries happen in remote locations, usually complex injuries that require expertise

- NASA
  - Going to Mars…

- Developing countries, mobile populations (nomads), geography (Norway, Canada, etc)

- Centres of competence (an vital part of modern medicine today)
Why telemedicine?

- **Economy**
  - Efficiency, less transportation
  - Hospital saves about $12 per patient because of digital images

- **Quality**
  - Accessibility, close to the patient, home care, access to expertise, faster treatment, second opinion

- **Environment**
  - A digital domain is clean

- **Enables new methods and practices**

- **Education is very important!**
  - Technology enables access to shared knowledge. Like your site visit to surgery
Why not telemedine?

- Technology still not available (true or false?)
- Available data is still analogue; no potential for tele-
- Bandwidth (still an issue, specifically for real time).
  - 256 x 256 x 12 (CT), about 100kB
  - 2048 x 2048 x 12 (Lung x-ray), about 6MB
- Digital storage formats are complex (huge, expensive)
- Security (encryption, access control, firewalls)
Exchange of information is not always easy

- Patient record is not available when medical staff needs it
  - Is located in another system
  - Is in Sweden, when the skier is injured in the Alps

- Information is actually available, but cannot be read
  - Lack of standards
  - Specific to the device producer (proprietary)
  - A standard format, but different from what you are using
  - The same standard format, but in a different version
  - The same standard and version, but not correctly implemented
  - Unknown format, or something made up (actually quite common)
Why don’t we use GIF?

- Image data (compressed or raw)
- Patient information (= id)
- Technical information
  - Modality
  - Settings
  - Geometry
  - Fluids and their state
  - Series, study, number
How do we store images

- **Fix format**
  - All files have the same layout

- **Block format**
  - Header contains pointer to contents in file

- **Tag format**
  - Every part of the file has a start and end

# ACR/NEMA (tag format)

<table>
<thead>
<tr>
<th>Tag</th>
<th>Description</th>
<th>Format Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000</td>
<td>Command</td>
<td></td>
</tr>
<tr>
<td>0008</td>
<td>Identifying</td>
<td></td>
</tr>
<tr>
<td>0010</td>
<td>Patient</td>
<td></td>
</tr>
<tr>
<td>0018</td>
<td>Acquisition</td>
<td></td>
</tr>
<tr>
<td>0020</td>
<td>Relationship</td>
<td></td>
</tr>
<tr>
<td>0028</td>
<td>Image Presentation</td>
<td></td>
</tr>
<tr>
<td>4000</td>
<td>Text</td>
<td></td>
</tr>
<tr>
<td>6000-601E</td>
<td>Overlay</td>
<td></td>
</tr>
<tr>
<td>7FE0</td>
<td>Pixel Data</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**
- **(0008,0010)** AT S Recognition Code  
  - ACR-NEMA 1.0 or 2.0
- **(0008,0020)** AT S Study Date  
  - yyyy.mm.dd
- **(0008,0021)** AT S Series Date  
  - yyyy.mm.dd
- **(0008,0022)** AT S Acquisition Date  
  - yyyy.mm.dd
- **(0008,0023)** AT S Image Date  
  - yyyy.mm.dd
- **(0008,0030)** AT S Study Time  
  - hh.mm.ss.frac
- **(0008,0031)** AT S Series Time  
  - hh.mm.ss.frac
- **(0008,0032)** AT S Acquisition Time  
  - hh.mm.ss.frac
- **(0008,0033)** AT S Image Time  
  - hh.mm.ss.frac
- **(0008,0060)** AT S Modality  
  - CT, NM, MR, DS, DR, US, OT
- **(0010,0010)** AT S Patient Name  
- **(0010,0020)** AT S Patient ID  
- **(0010,0030)** AT S Patient Birthdate  
  - yyyy.mm.dd
- **(0010,0040)** AT S Patient Sex  
  - M, F, O for other
- **(0010,0100)** AT S Position Reference  
  - eg. iliac crest
- **(0018,0010)** AT M Contrast/Bolus Agent  
  - or NONE
- **(0018,0030)** AT M Radionuclide  
- **(0018,0050)** AN S Slice Thickness  
  - mm
- **(0018,0060)** AN M KVP  
- **(0018,0080)** AN S Repetition Time  
  - ms
- **(0018,0081)** AN S Echo Time  
  - ms
- **(0018,0082)** AN S Inversion Time  
  - ms
- **(0018,1120)** AN S Gantry Tilt  
  - degrees
- **(0020,1000)** AT M Pixel Size  
- **(0020,1001)** AT M Pixel Representation  
- **(0028,0010)** BI S Rows  
- **(0028,0011)** BI S Columns  
- **(0028,0030)** AN M Pixel Size  
  - row\col in mm
- **(0028,0100)** BI S Bits Allocated  
  - eg. 12 bit for CT
- **(0028,0101)** BI S Bits Stored  
  - eg. 16 bit
- **(0028,0102)** BI S High Bit  
  - eg. 11
- **(0028,0103)** BI S Pixel Representation  
  - 1 signed, 0 unsigned
!INTERFILE :=
!imaging modality :=nucmed
!version of keys :=3.3
data description :=static
patient name :=joe doe
!patient ID :=12345
patient dob :=1968:08:21
patient sex :=M
!study ID :=test
exam type :=test
data compression :=none
!image number :=1
!matrix size [1] :=64
!matrix size [2] :=64
!number format :=signed integer
!number of bytes per pixel :=2
!image duration (sec) :=100
image start time :=10:20:0
total counts :=8512
!END OF INTERFILE :=
DICOM

- Digital Imaging and Communications in Medicine (DICOM).
  - http://medical.nema.org/

- Conformance statement

1. Introduction and Overview.
2. Conformance.
3. Information Object Definitions.
4. Service Class Specifications.
5. Data Structure and Encoding.
Teleradiology

- Transfer images between radiologists
  - Second opinion
  - The number of experts is limited; easy access
  - Some diagnostics must be made quickly
TELEMEDICINE EXAMPLE
Medicus

- Ordered by the Deutsche Telekom.
- Wanted to create products that would sell ISDN lines, as an added value to that kind of (phone) subscriptions.

**Specification:**
- Teleconference.
- Exchange of images.
Early requirements

- **The buyer:**
  - Must use ISDN
  - Conference
  - ”Sell”

- **Medical staff:**
  - As before, but better
  - In case of emergency
  - See the other colleague
    - Video and sound
  - Share ”pointer”
Medicus, design
Medicus, look&feel
Later requirements

- Huge image
- Big image
- Functionality
- Usable
- Affordable
Example of use

Krankenhaus Salem

Onkologische Diagnostik
Deutsches Krebsforschungszentrum
Start of application

![Bar chart showing start times of application process at different times of day. The chart peaks around 11:00 and 13:00, with lower activity in the early morning and late evening.]
Length of conference

- < 1 min
- 1-2 min
- 2-3 mins
- 3-4 min
- 4-5 min
- 5-10 min
- 10-15 min
- 15-20 min
- 20-25 min
- > 25 min
New development
Decision support
Decision Support Systems

- Administrative
  - Classification and documentation

- Complexity
  - Keeping patients on protocols
  - Referrals

- Cost
  - Medication, alternative procedures

- Decision
  - Diagnosis and treatment
  - Best practices
  - Guidelines
### Läkemedelslista, ATC-sorted

* anal kvalitetspåpekanden, (sidhänvisning FAS-UT)*

- A: Wilzin, Kaps hårda, 50 mg
- M: Iren, Filmdrag tabl, 600 mg ***** (s. 98)
- N: Magnecyl, Tabl, 500 mg ****
  - Alvedon, Munsöndtabl, 250 mg (s. 124)

**ANTAL PREPARAT:** 4
**ANTAL OLika Läkemedel:** 4

---

### Diagnoser/symtom (Frågeformuläret)

- Har patienten hjärtsvikt? NEJ
- **Har patienten anamnes på GERD eller ulcer sjukdom? JA**
- **Har patienten artros? JA**
- **Har Patienten nedsatt njurfunktion? NEJ**

---

### Socialstyrelsens kvalitetsindikatorer

1. Läkemedelsffspecifika indikatorer

1.2 **Preparat vars användning kräver en korrekt och aktuell indikation**
   - **1.2.1 NSAID**
     - Iren

1.3 **Olämplig regim**
   - **1.3.2 NSAID dagligen under mer än tre månader utan omprövning?**
     - Iren

1.6 **Läkemedelskombinationer som kan leda till interaktioner av klinisk betydelse**
   - C- och D-interaktioner
     - Magnecyl, Iren, [D2] *1*
Läkemedelslista, ATC-sorterad
* anal kvalitetspåpekanden, (sidhänvisning FAS-UT)

A: Wilzin, Kaps hårdf, 50 mg
M: Ipren, Filmdrag tabl, 600 mg **** (s. 98)
N: Magnecyl, Tabl, 500 mg ***
Alvedon, Munsöndtabl, 250 mg (s. 124)

ANTAL PREPARAT: 4
ANTAL OLKA LÄKEMEDEL: 4

Diagnoser/symtom (Frågeformuläret)
- Har patienten hjärtsvikt? NEJ
- Har patienten anamnes på GERD eller ulcussjukdom? JA
- Har patienten artros? JA
- Har Patienten nedsatt njurfunktion? NEJ

Socialstyrelsens kvalitetsindikatorer

1. Läkemedelsspecifika indikatorer

1.2 Preparat vars användning kräver en korrekt och aktuell indikation
  1.2.1 NSAID
  Ipren

1.3 Olämplig regimen
  1.3.2 NSAID dagligen under mer än tre månader utan omprövning?
  Ipren

1.6 Läkemedelskombinationer som kan leda till interaktioner av klinisk betydelse
  C- och D-interaktioner
  Magnecyl, Ipren [D2] *1

Potentiala läkemedelsinteraktioner (klass C och D)
- Dubbliering av läkemedel
- Läkemedel med antikoagulativa egenskaper
- Långvarande benzodiazepiner

ATC-sortering
C3C4 D3D4 Kvalitetssortering

Automatisk telesvaningskontroll (aktiv)
Example: Web-based Artificial Intelligence for Diagnostic Use
Background

- In the western world, myocardial disease is very common (and growing).
- It is treatable, but accurate and fast diagnosis is important.
- It is hard to make a diagnosis
  - http://www.montana.edu/wwwai/imsd/diabetes/myocard.htm
Basis for diagnosis

- Medical history
- Earlier examinations
- Images of the heart
- Electrocardiogram, ECG (easy to use but not optimal)
Background

1895 - Wilhelm Conrad Röntgen discovers that “bremsstrahlung” will discolor film
1896 - Henri Becquerel discovers radioactivity
1900 - Villard discovers gamma radiation
1938 - isotope Technetium-99m tagged to a pharmaceutical that transports it to its required location
1946 – radioactive substance used in a hospital for the first time
1957 - Hal Anger develops the first gamma camera

http://en.wikipedia.org/wiki/Gamma_camera
Myocardscintigraphy

- Meaning…
  - myos; cardia; scintillation; grafein
  - muscle; heart; flash; draw
- Radioactive substance (Technetium-99m; gamma radiation 140 keV; half-life 6h), injected in the blood
- Working cells absorb the most
- Image is captured by measuring radiation
Omelet?

- 4 eggs
- Salt & pepper?
- A hint of technetium-99m
Results

- Image is reconstructed by different angles
- One image for rest, one for stress
Problem

- Not all physicians get enough training making interpretations
- To become good (expert) requires a lot of training
- Not all clinics have access to an expert
- Help is not always available when needed
- Healthcare cannot always afford to invest in DSS
- DSS can be difficult to use
Automatic interpretation

- Artificial neural networks (ANN)

Examples of patients > Train! > ANN > Test! > A new patient
The image shows a software interface titled "WeAidU". The interface includes a file explorer with options to select files such as "a.ifi", "demo.ifi", and "demo_ebe.dcm". The selected file is "demo.ifi".

Below the file explorer, there is a section labeled "Result" with a table that includes columns for "FIRS", "Probability", "Interpretation", "SURNAME", and "1212121212". The table contains the following data:

- **FIRS**
  - Infarct LAD: 0.21, No
  - Infarct LCX: 0.51, Uncertain
  - Infarct RCA: 0.26, No
  - Ischemia LAD: 0.07, No
  - Ischemia LCX: 0.04, No
  - Ischemia RCA: 0.1, No

The interface also shows two circular diagrams labeled "Stress" and "Rest". There are buttons for "Add to archive", "Show to Dr. Kartfell", and "Done".

The interface is set against a red background with the text "Uppsala university" at the top and "UU/IT" at the bottom.
EXINI heart™

This is a computer-based interpretation and EXINI takes no responsibility for its use.

Consider to:
Include anterior ischemia

Edit report
Think about

- What happens when the technology breaks down?