Telemedicine  Erik Borälv
Today…

- Telemedicine
  - What it is
  - What do we as IT-experts need to know
  - An example 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.
Why use telemedicine?

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

- **NASA**
  - They plan to go to Mars…

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

- **Centres of competence (an vital part of modern medicine today)**
Rationale

- **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
Problems today

- Technology not available (true or false?)
- Available data is still analogue; no potential for *tele*
- Bandwidth (still an issue, specially 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)
Basic telemedicine

- Phone
- Phone + TV (video conference)
  - Education
  - Emergency, live broadcast from trauma rooms
  - Consultation with patient present, a sort of interactive decision support
Exchange of information is not always easy

- EPR not available when medical staff needs it
  - Is located in another system
  - Is in Sweden, when the skier is injured in Austria

- Information is 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)
Image formats standards may help

- Sadly not. Pick your standard…
  - Interfile (common in nuclear medicine)
  - De facto (Philips, Siemens, GE, …)
  - Your own format
  - DICOM

Why don’t we use GIFs?

- 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>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000</td>
<td>Command</td>
<td></td>
</tr>
<tr>
<td>0008</td>
<td>Identifying</td>
<td>(0018,0010) AT M Contrast/Bolus Agent</td>
</tr>
<tr>
<td>0010</td>
<td>Patient</td>
<td>(0018,00030) AT M Radionuclide</td>
</tr>
<tr>
<td>0018</td>
<td>Acquisition</td>
<td>(0018,0050) AN S Slice Thickness</td>
</tr>
<tr>
<td>0020</td>
<td>Relationship</td>
<td>(0018,0060) AN M KVP</td>
</tr>
<tr>
<td>0028</td>
<td>Image Presentation</td>
<td>(0018,0080) AN S Repetition Time</td>
</tr>
<tr>
<td>4000</td>
<td>Text</td>
<td>(0018,0081) AN S Echo Time</td>
</tr>
<tr>
<td>6000-601E (even)</td>
<td>Overlay</td>
<td>(0018,0082) AN S Inversion Time</td>
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<tr>
<td>7FE0</td>
<td>Pixel Data</td>
<td>(0018,1120) AN S Gantry Tilt</td>
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<tr>
<td></td>
<td></td>
<td>(0020,1040) AT S Position Reference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0020,1041) AN S Slice Location</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0028,0010) BI S Rows</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0028,0011) BI S Columns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0028,0030) AN M Pixel Size</td>
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<tr>
<td></td>
<td></td>
<td>(0028,0100) BI S Bits Allocated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0028,0101) BI S Bits Stored</td>
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<td></td>
<td></td>
<td>(0028,0102) BI S High Bit</td>
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<tr>
<td></td>
<td></td>
<td>(0028,0103) BI S Pixel Representation</td>
</tr>
<tr>
<td>0008,0010</td>
<td>AT S Recognition Code</td>
<td># ACR-NEMA 1.0 or 2.0</td>
</tr>
<tr>
<td>0008,0020</td>
<td>AT S Study Date</td>
<td># yyyy.mm.dd</td>
</tr>
<tr>
<td>0008,0021</td>
<td>AT S Series Date</td>
<td># yyyy.mm.dd</td>
</tr>
<tr>
<td>0008,0022</td>
<td>AT S Acquisition Date</td>
<td># yyyy.mm.dd</td>
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<td>0008,0023</td>
<td>AT S Image Date</td>
<td># yyyy.mm.dd</td>
</tr>
<tr>
<td>0008,0030</td>
<td>AT S Study Time</td>
<td># hh.mm.ss.frac</td>
</tr>
<tr>
<td>0008,0031</td>
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<td># hh.mm.ss.frac</td>
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<tr>
<td>0008,0032</td>
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<td># hh.mm.ss.frac</td>
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<tr>
<td>0008,0033</td>
<td>AT S Image Time</td>
<td># hh.mm.ss.frac</td>
</tr>
<tr>
<td>0008,0060</td>
<td>AT S Modality</td>
<td># CT, NM, MR, DS, DR, US, OT</td>
</tr>
<tr>
<td>0010,0010</td>
<td>AT S Patient Name</td>
<td># yyyy.mm.dd</td>
</tr>
<tr>
<td>0010,0020</td>
<td>AT S Patient ID</td>
<td></td>
</tr>
<tr>
<td>0010,0030</td>
<td>AT S Patient Birthdate</td>
<td># yyyy.mm.dd</td>
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<tr>
<td>0010,0040</td>
<td>AT S Patient Sex</td>
<td># M, F, O for other</td>
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<tr>
<td>0010,1010</td>
<td>AT S Patient Age</td>
<td># xxxD or W or M or Y</td>
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</table>

@UU/IT
!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/
- Defines semantics for commands; a language.
- How to write an Conformance Statement.
- Multi part; has separate parts so that development can be done in parallel and faster.
DICOM, parts

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

- PACS  Picture Archiving and Comm System.
- CT    Computer Tomography.
- MR    Magnetic Resonance.
- XA    Angiography (Egas Moniz, Nobel Prize winner in 1949).
- US    Ultra Sound.
- Invasive Into the body.
- In vivo/vitro Alive/glass tube.
- Serie, study Hierarcy.
- Modality Image capture (camera).
A CT/modality
Teleradiology

- Transfer images between radiologists
- X-ray diagnostics

Idea:
- Second opinion
- The number of experts is limited; easy access
- Some diagnostics must be made quickly
Good "misuse": the system is used for something different than intended:

- Education
- Replace film
- Send images in advance
- Physician on call, maybe at home
- Centre of competence
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

DKFZ 27-03-95 (08.30) Dr. Lange
DKFZ 15-03-95 (14.00) Dr. Watson
UAS 10-03-95 (21.19) Dr. Berg
DKFZ 27-03-95 (08.30) Dr. Lange
DKFZ 03-01-95 (12.09) Dr. Meinzermann

Make a call

Dr. Borelf (London)
Dr. Gump
Dr. Pulp
Dr. Mabuse
Call somebody else...

Dr. Gump

Exit Medicus
Later requirements

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

Krankenhaus Salem

Onkologische Diagnostik
Deutsches Krebsforschungszentrum
Start of application
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

Bar chart representing the distribution of conference lengths.
New development
CHILI PDA, v.1
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
Läkemedel, ATC-sorterad
* antal kvalitetspåpekanden, (sidhänvisning FAS-UT)

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

antal preparat: 4
antal olika läkemedel: 4

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

Socialstyrelsens kvalitetsindikatorer

1. Läkemedelspecifika indikatorer

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

1.3 Oliämplig regimen
   1.3.2 NSAID dagliga under mer än tre månader utan omprövning?
   Ipyen

1.6 Läkemedelskombinationer som kan leda till interactioner av klinisk betydelse
   C- och D-interaktioner
   Magnecyl, Ipyen [D2] *1
### LAKEMEDELSLISTA, ATC-sorterad

* Antal kvalitetspåpekanden, (sidhanvisning PÅS-UT)

** A: Wilzin, Kaps hårda, 50 mg
** M: Ipern, Filmdrag tabl, 600 mg **** (s. 98)
** N: Magnecyl, Tabl, 500 mg ***

ANTAL PREPARAT: 4
ANTAL OLIKA LAKEMEDEL: 4

### Diagnoser/symtom (Frågeformuläret)

- Har patienten hjärtsvikt? **NEJ**
- Har patienten anamnes på GERD eller ulcerjukdom? **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
   Ipern

1.3 **Oliämplig regimen**

   1.3.2 NSAID dagligt under mer än tre månader utan omprövning?
   Ipern

1.6 **Läkemedelskombinationer som kan leda till interaktioner av klinisk betydelse**

   - C- och D-interaktioner
   Magnecyl Ipern [D2] *1
EXINI heart™

Ischemia
- Anterior
- Septal
- Inferior
- Lateral
- Apical

Infarct
- Anterior
- Septal
- Inferior
- Lateral

Advice

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?
- Ethical aspects of DSS?
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 an 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
### Infarct

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<thead>
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<th>Area</th>
<th>Physician</th>
<th>WeAidU</th>
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</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Inferior</td>
<td>Absent</td>
<td>Absent</td>
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<tr>
<td>Apical</td>
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<td>Absent</td>
</tr>
<tr>
<td>Septal</td>
<td>Equivocal</td>
<td>Possibly present</td>
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<tr>
<td>Lateral</td>
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### Ischemia

<table>
<thead>
<tr>
<th>Area</th>
<th>Physician</th>
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<tbody>
<tr>
<td>Anterior</td>
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</tr>
<tr>
<td>Inferior</td>
<td>Absent</td>
<td>Absent</td>
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<tr>
<td>Apical</td>
<td>Probably absent</td>
<td>Probably absent</td>
</tr>
<tr>
<td>Septal</td>
<td>Probably present</td>
<td>Probably present</td>
</tr>
<tr>
<td>Lateral</td>
<td>Probably absent</td>
<td>Absent</td>
</tr>
</tbody>
</table>

**Note:** This is a computer-based interpretation and WeAidU takes no responsibility for its use.

### DISCLAIRMER:
This is a computer-based interpretation and WeAidU takes no responsibility for its use.