Telemedicine  Erik Borälv
Today…

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

- 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.
  - XX saves about $12 per patient because of digital images

- **Quality.**
  - Accessability, 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 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 the cellar of the hospital
  - Is in Sweden, when the skier is in Austria
  - Is at the family doctor’s, but not near the ER

- 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…
  - ACR/NEMA
    - American College of Radiologists (ACR), National Electrical Manufacturers Association (NEMA)
  - 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)

0000 Command
0008 Identifying
0010 Patient
0018 Acquisition
0020 Relationship
0028 Image Presentation
4000 Text
6000-601E (even) Overlay
7FE0 Pixel Data

---------------------------------------------------------------

(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 Patient Age            # xxxD or W or M or Y
(0018,0010) AT M Contrast/Bolus Agent    # or NONE
(0018,0020) 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
(0020,1040) AT S Position Reference      # eg. iliac crest
(0020,1041) AN S Slice Location          # in mm (signed)
(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).

- **ACR** (American College of Radiology) and **NEMA** (the National Electrical Manufacturers Association) formed a joint committee to develop a Standard for Digital Imaging and Communications in Medicine.

- [http://medical.nema.org/](http://medical.nema.org/)
DICOM, history

- In the 1970s digital modalities started to arrive.
- A need for transfer of digital images.
- Image transfer lead to a number of new areas:
  - Security.
  - Terminology.
  - Referrals, payments to others.
  - Who owns the image?
  - Send images to other hospitals or countries?
DICOM, content

- Network; used to be point-to-point (= copper wire)
- 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** Hierarchy.
- **Modality** Image capture (camera).
A CT/modality
Teleradiology

- Transfer images between radiologists.
- X-ray diagnostics.

Idea:
  - Second opinion
  - The number of experts is limited
  - Some diagnostics must be made quickly
Teleradiologi, part 2

- 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
Telepathology

- Examines tissue.
- Tissue is frozen and are generally fragile (to transport).
- Extreme quality of images is required (microscope).
- External control of microscope - light, position, magnification, pan, etc.
Telepathology

- It takes 20 minutes from when the surgeon in Lycksele cuts an sample until the pathologist in Umeå has analyzed the sample and made a diagnose.

- The surgeon gets advice during the surgery whether he/she shall continue.
  - A sample is taken
  - The chem.lab prepares the sample, frozen and cut
  - A microscope is remote controlled by a pathologist in Umeå
  - Notice goes to the surgeon, that can act based on better information
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
Length of conference

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

- Administrative
  - Coding and documentation
- Complexity
  - Keeping patients on protocols
  - Referrals
- Cost
  - Medication
- Decision
  - Diagnosis and treatment
  - Best practices
  - Guidelines
Läkemedel, ATC-sorteder
* antal kvalitetspruebaorden, (innehållsvärden PAS UT)

A: Wilkin, Kaps hård, 50 mg
M: Ipöer, Försäkring tabl, 600 mg **** (s. 98)
N: Magnecyl, Tabel, 500 mg ***
   Alvedon, Musgub tabl, 250 mg (s. 124)

ANTAL PREPARAT: 4
ANTAL OLIKA LÄKEMEDEL: 4

Diagnoser/symtom (Frågeformuläret)
- Har patienten hjärtväkt? NEJ
- Har patienten ansnom på GERD eller ulcerjukdom? JA
- Har patienten artror? JA
- Har patienten nedsett njurfunktion? NEJ

Socialstyrelsens kvalitetsindikatorer

1. Läkemedelspezifika indikatorer

1.2 Preparatvarav användning kräver en korrekt och aktuell indikation
   1.2.1 NSAID
   Ipin

1.3 Olika regler
   1.3.2 NSAID dagliga under mer än tre månader utan omprövning?
   Ipin

1.4 Läkemedelskombinationer som kan leda till interaktioner av klinisk betydelse
   C- och D-interaktioner
   Magnecyl Ipin [D2] *1
Läkemedel lista, ATC-sorterad
* antal kvalitetsuppskott, (inklusive PARS) UT)

A: Wilkin, Kaps hårld, 50 mg
M: Iren, Fyllings tabl, 600 mg **** (s. 98)
N: Magnecyl, Tabl, 500 mg ***
Alvedon, Munsuk tabl, 250 mg (s. 124)

ANTAL PREPARAT: 4
ANTAL OLIKA LÄKEMEDEL: 4

Diagnoser/symtom (Frågeformuläret)
- Har patienten hjärtvik? NEJ
- Har patienten ansnus på GERD eller ulcerulcer? JA
- Har patienten astma? JA
- Har Patienten redan njurfunktion? NEJ

Socialstyrelsens kvalitetsindikatorer

1. Läkemedels specifika indikatorer

1.2 Preparatvars användning kräver en korrekt och aktuell indikation
1.3 NSAID

1.3.2 NSAID dagligen under mer än 3 månader utan omprövning?

1.6 Läkemedel kombinationer som kan leda till interaktioner av klinisk betydelse
C- och D-interaktioner
Magnecyl Iren [D2] *)
Think about

- What happens when the technology breaks down?
- Ethical aspects of DSS?

- The sensitivity (also called recall rate in some fields) measures the proportion of actual positives which are correctly identified as such (i.e. the percentage of sick people who are identified as having the condition); and the specificity measures the proportion of negatives which are correctly identified (i.e. the percentage of well people who are identified as not having the condition).
Reading

- [http://www.coiera.com/aimd.htm](http://www.coiera.com/aimd.htm)
- [http://www.openclinical.org/home.html](http://www.openclinical.org/home.html)
  - [http://jnm.snmjournals.org/cgi/content/abstract/38/12/1870?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&fulltext=edenbrandt&searchid=1&FIRSTINDEX=0&sortspec=relevance&resourcetype=HWCIT](http://jnm.snmjournals.org/cgi/content/abstract/38/12/1870?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&fulltext=edenbrandt&searchid=1&FIRSTINDEX=0&sortspec=relevance&resourcetype=HWCIT)
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
Myokardscintigrafi

- **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

ANN

Train!

A new patient

Test!
### Infarct

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### Ischemia

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WeAidU

**Patient's ID**: 31000000101
**Date**: 000000001
**WeAidU Ref**: 3090

**Infarct**

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**Ischemia**

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