Digital Imaging in Contemporary Healthcare

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Some milestones in Digital Medical Imaging (approximate years)

<table>
<thead>
<tr>
<th>Year</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>PET/MR</td>
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<tr>
<td>2007</td>
<td>Digital tomosynthesis</td>
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<tr>
<td>2002</td>
<td>3T MRI</td>
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<td>2001</td>
<td>PET/CT</td>
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<tr>
<td>2000</td>
<td>SPECT/CT</td>
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<td>1999</td>
<td>Digital mammography</td>
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<td>1998</td>
<td>Multislice CT</td>
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<td>1996</td>
<td>VHF Digital Ultrasound</td>
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<td>1995</td>
<td>DR Flat panel system</td>
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<td>1993</td>
<td>Functional MRI</td>
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<td>1990</td>
<td>Spiral CT</td>
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<tr>
<td>1988</td>
<td>EPID</td>
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<tr>
<td>1983</td>
<td>CR systems</td>
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<td>1981</td>
<td>PET Scanner</td>
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<tr>
<td>1980</td>
<td>MR scanner</td>
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<tr>
<td>1979</td>
<td>DSA</td>
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<tr>
<td>1978</td>
<td>SPECT</td>
</tr>
<tr>
<td>1972</td>
<td>CT scanner</td>
</tr>
<tr>
<td>1969</td>
<td>Ultrasound Scanner</td>
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</tbody>
</table>

Main technology drivers:
- Computer systems
- Reconstruction software
- Digital detectors
- Hospital Networks (PACS)

Main healthcare drivers:
- Precise diagnostics
- Increased patient throughput
- Decreased cost

New medical speciality (Imaging)
Rapid Medical Physics development
Main advantages of Digital Medical Imaging

- Reconstruction allows unique view inside the body (non-destructive testing)

- Dramatically improved contrast resolution
  CT (and DR) - 10 times better Contrast compared with classical Radiography

- Dramatically increased image dynamics (1:10 000)

- Physiological imaging (Functional Imaging)
Main advantages of Digital Medical Imaging

- Various measurements from the image

- Image fusion (from various modalities)

Main advantages of Digital Medical Imaging

- Image post-processing / reconstruction

- New Working environment
Main advantages of Digital Medical Imaging

- Methods without Patient dose

- Potential for substantial Patient Dose reduction (compared with classical)
  - Digital radiography ~80% reduction of dose
  - Digital fluoroscopy ~ 90% reduction of dose

Main advantages of Digital Medical Imaging

- Increased patient throughput (and mass screening) – time for image available
  - 16 sec per DR img.; 6 minutes per CR img.; 10+ minutes per classical img.

- Digital archive (PACS) with enormous capacity
Main advantages of Digital Medical Imaging

- Reduced cost per investigation (mainly due to eliminating film & film processing plus associated staff cost)
Main challenges of Digital Medical Imaging

- Large number of new methods and necessity of constant re-training
- Reducing the Imaging staff (due to equipment automatisation)
- Change in the organisation of work in Imaging Departments/Hospitals
- Increased cost of equipment and rooms for it
  (currently ~10% of all hospital budget is associated with Imaging equipment)
- Increased number of investigations (and Patient Dose !)
  CT and Interventional Radiology – the highest patient doses
- Image processing changes the 'real image' (can’t be used as evidence)

The global trend of increase in Digital Medical Imaging has a strong drive in the number of conventional X-ray equipment, to be turned digital.

Some countries started late, but the trends are preserved.
Recent figures for the trend in development of Digital Medical Imaging

2007: Manufacturing of flat panels (DR) planned to increase with 40%

USA (2005-06) – 4860 hospitals with 16,500 radiography systems
  From these: 42% plan to buy new DR;
  24% are planning to buy DR or CR,
  11% plan to buy film systems

Cost of European markets for CR system in 2009 – 228 M$
  $predicted for 2016 – 237 M$ (0.6% growth)

Cost of European markets for DR system in 2009 – 68 M$
  $predicted for 2016 – 111 M$ (7.2% growth)

Number of CT procedures performed per year in England -a) and in the USA -b) between 1998 - 2007.

2001: Relative frequency of different procedures in Germany – on left and their relative contribution to the collective effective dose - on right.
Conclusion:
- The ‘Digital Revolution’ has increased enormously the breadth of knowledge for Medical Imaging (almost as in a separate profession)
- During the past 10 years the number of Digital Medical Imaging systems surpassed the number of Classical Medical Imaging Systems (globally)
- This ‘Revolution’ led to 90%+ Digital Medical Imaging in developed countries, but this ratio is still below 50% for the developing countries
- In the next 10 years almost all Medical Imaging systems will be Digital (globally)
- This has reflected the education and training of Medical Physicists and Engineers (as well as Radiologists)
- The education/training (and work pattern) of radiographers also changes rapidly
- The study of Digital Systems will have to include Hospital Networks and PACS
- An important issue for further development is extraction of information from digital images (through special processing and measurements)
- The systems for Image Hard Copying will continue to be developed
- A very important issue is still Radiation Dose associated with Digital Medical Imaging systems (specially due to the new opportunities for diagnosis)