Applied Math 4380/5380 **Modeling; Project assignment 1** **Posted 08/28/09**
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The following are some suggested individual 'read-and-tell' projects in the general area of noninvasive imaging. Select a topic (or, if you wish, propose a different one).

- Read up on the topic,
- Explain the topic to the class (in about 10 minutes; aim towards being ready during the week following Labor Day, i.e. about 1½ weeks from now),
- Prepare an electronic version, in any format that is suitable for posting on the class web page (for ex. Powerpoint or .pdf; This version does not need to show your name if you prefer this not to be web visible).

A web search is often the most efficient way of collecting information and references.

Some suggestions for topics:

1. The pioneering work on X-ray tomography by A.M. Cormack.
   Tell briefly about Cormack's career. His proposed inversion technique is different from any we will discuss in class (technically difficult and not very effective). His two seminal papers appeared in *Journal of Applied Physics*, vol. 34, no 9, 1963 and vol. 35, no 10, 1964.

2. The pioneering work on X-ray tomography by Sir G. Hounsfield.
   Tell briefly about Houndsfield's career. His work led to the first CT machine in clinical use (Wimbledon 1971). See for ex. Hounsfield, G.N. "Computerized transverse axial scanning (Tomography): Part 1. Description of the system", *British Journal of Radiology*, vol. 16 (1973), pp 210-224 and Spencer, K.A. "Computer tomography - an overview", *Journal of Photographic Science*, vol. 37 (1989), pp 84-85.

3. The life and work by John Radon.
   A good book on this is "75 Years of the Radon Transform", ed. Gindikin and Michor, International Press Inc, Boston, 1994 (I have a copy that I can lend out).

4. Developments in medical CT equipment from first installation to current state-of-the-art.
   Trace the history of how capabilities, resolution, general performance, range of applications etc. have evolved during the soon 40 years that such equipment has been in medical use.

5. Current state-of-the-art in medical ultrasound imaging.

6. Magnetic resonance imaging.
   There is a lot of readily available material on MRI in popular magazines and books. An old, but nice reference is "NMR imaging in medicine" by Pykett, Scientific American vol. 246, No 5, 1982.

7. MEG - Magnetoencephalography.
   One article on this topic is Hämäläinen, M., Hari, R., Ilmoniemi, R.J., Knuutila, J. and Lounasmaa, O.V., "Magnetoencephalography - theory, instrumentation, and applications to noninvasive studies of the working human brain", *Reviews of Modern Physics*, vol. 65, no 2, 1993, pp 413-497. Also of interest Crease, R.P. "Images of conflict: MEG vs. EEG", *Science*, vol. 253, pp 374-375 (subtitle: The father of a new brain-imaging method has become its severest critic - producing controversy in an emerging field). Both of these references are quite old - there should be plenty of more recent developments.

8. Seismic tomography.

Seismic tomography allows the mapping of slow magma flows in the earth's mantle - these movements drive the tectonic plates and are ultimately the cause of earth quakes.
Old but good reference: Anderson, D.L. and Dziewonski, A.M. "Seismic tomography", *Scientific American*, Oct. 1984, vol. 251. Look for newer ones!

9. Ocean acoustic tomography.
In ocean acoustic tomography, one generates and then records sound waves crisscrossing the oceans. This allows for ex. currents and variations in temperature, salinity, and density throughout oceans be determined from shore-based measurements. References include: Spindel, R.C. and Worcester, P.F. "Ocean acoustic tomography", *Scientific American*, Oct. 1990, vol. 263, and the book: Munk, W., Worcester, P. F., and Wunsch, C. (1995), *Ocean acoustic tomography*, Cambridge University Press.

10. Astronomical tomography.
One application is the study of accretion discs - a key process in which mass falls towards a central object and in the process gives rise to various exotic phenomena.

11. Tomographical space telescope
Telescope mirrors traditionally tend to be circular. There are two main reasons to also make them very large: (i) to collect more light from very faint objects, and (ii) to increase resolution, otherwise limited by diffraction properties of light. This tomographic telescope design offers an intriguing possibility of achieving extremely high resolution for relatively bright objects with a primary mirror that only need to be a long reflective strip rather then a full circular design. This would seem to be extremely well suited for use as a space-based telescope, but no practical experiments and designs have yet been made. It is described at http://www.pages.drexel.edu/~garfinkm/Scope.html .

12. Optical coherence tomography.

13. Electrical resistivity tomography.

14. Some additional tomography applications.

15. Some medical imaging technique not described in class.
This includes for example visualization by means of gamma cameras.

16. Nobel Prizes.
A.M. Cormack and Sir G. Hounsfield shared the 1979 Nobel Prize in Physiology and Medicine for their development of medical tomography. The 1952 prize in physics was shared by E. Purcell and F. Bloch for their work on NMR. I believe other discoveries related to NMR, PET (involving emission and annihilation of positrons), MEG (needing SQUIDS with Josephson junctions), etc. may also have lead to Nobel Prizes. Check the Nobel Prize records, and summarize what awards have been given that have significant connections to noninvasive imaging.

17. Safety record of different noninvasive methods.
Ultrasound used to be considered extremely safe, until a recent study showed that two fetal scans during a pregnancy increased the child's likelihood to be left handed by about 32%. A single full CT body scan exposes patients to about 13 milligrays of radiation - about the same exposure level as suffered by people 1½ miles from the WW II atomic blasts at Hiroshima and Nagasaki, and leading to a fatal cancer in one in every 1,250 45-year olds. PET, with matter/antimatter annihilations occurring within the brain tissue sounds also a bit worrying. MRI seems to have a good safety record. Collect some materials that compare different noninvasive methods from a safety point of view.

18. Propose your own topic in the general area of noninvasive imaging