CS 4873: Computing, Society & Professionalism

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Week 1: Case Study: Therac-25
January 8, 2020

Homework 1

- Available on class website: http://www.munmund.net/courses/spring2020/Assignment_I.pdf
- Due: January 15, 2020 (11:59pm Eastern Time)
- Submission on Canvas.

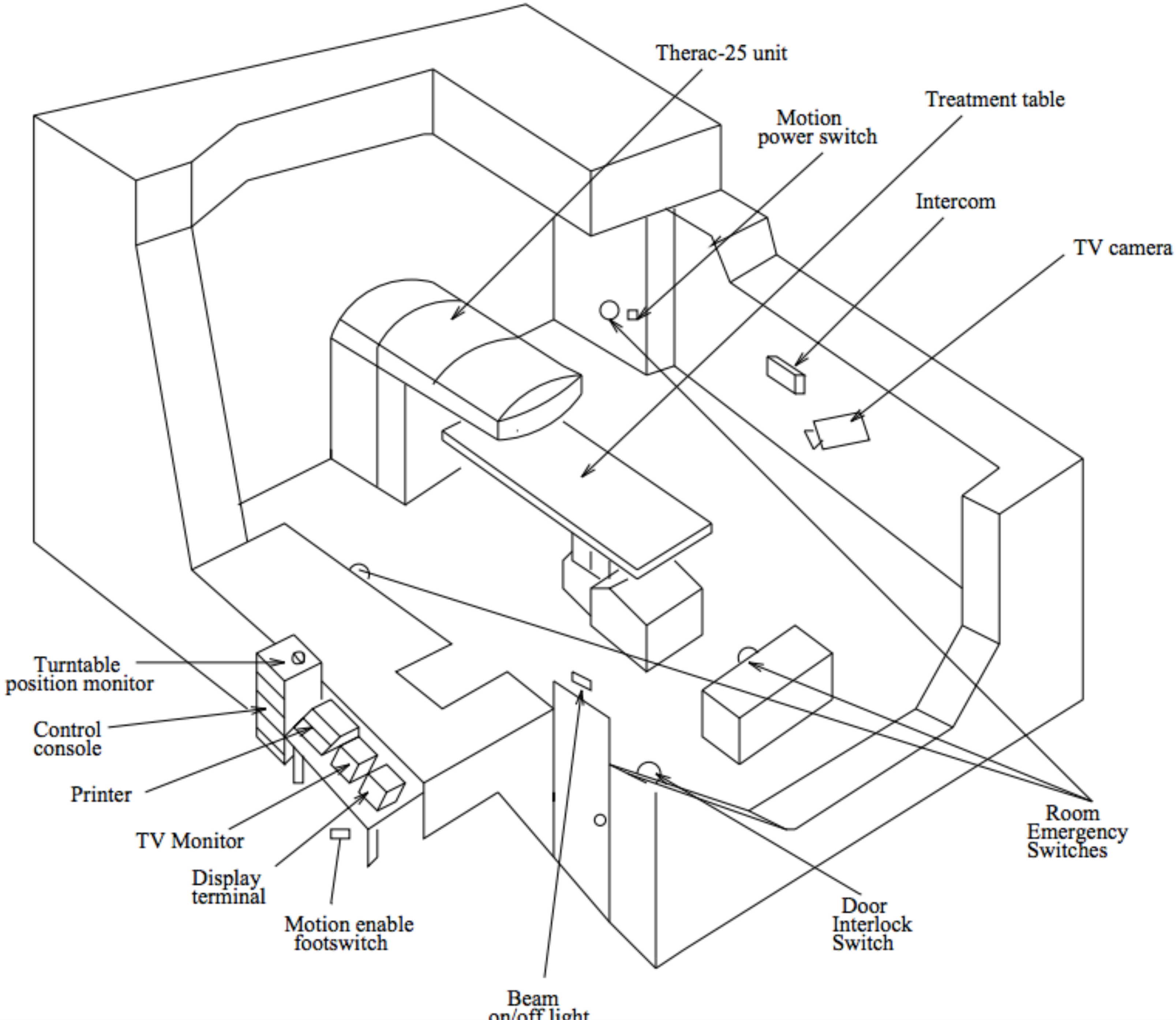
What is Ethics?

- The word ethics comes from the Greek word ethos meaning customs or habits
- Ethics is also known as moral philosophy
- In other words, ethics means the science of customs or habits of society

Why you, as a CS major need to know about ethics…

* Genesis of the Therac-25

- Atomic Energy of Canada Ltd (AECL) and French company CGR built Therac-6 and Therac-20
  - Delivered 25 MeV photons or electrons of various energies
- History before Therac-20
  - Software to convenience hardware
- Therac-25 built by AECL
  - Tensions between the two orgs
  - PDP-11 an integral part of system
  - Hardware safety features replaced with software
  - Reused code from Therac-6 and Therac-20
  - Compact, economic advantage
- First Therac-25 shipped in 1983
  - Patient in one room
  - Technician in adjoining room


Therac-25 unit
Motion power switch
Treatment table
Intercom
TV camera
Turntable position monitor
Control console
Printer
TV Monitor
Display terminal
Motion enable footswitch
Beam on/off light
Door Interlock Switch
Room Emergency Switches

Operation

- The radiation software required that **three essential programming instructions** be saved in sequence:
  - first, the quantity or dose of radiation in the beam;
  - then a digital image of the treatment area; and
  - finally, instructions that guide the multileaf collimator.

- Electron mode
  - 5-25 MEV
  - Magnets spread beam
  - Ion chamber monitor
- X-ray mode
  - 25 MEV electrons hit target
  - “Beam flattener” attenuates
  - 100x beam current
  - Ion chamber monitor
- Field-light mode
  - No current
  - Mirror & light used to check alignment
  - No ion chamber (since not treating)

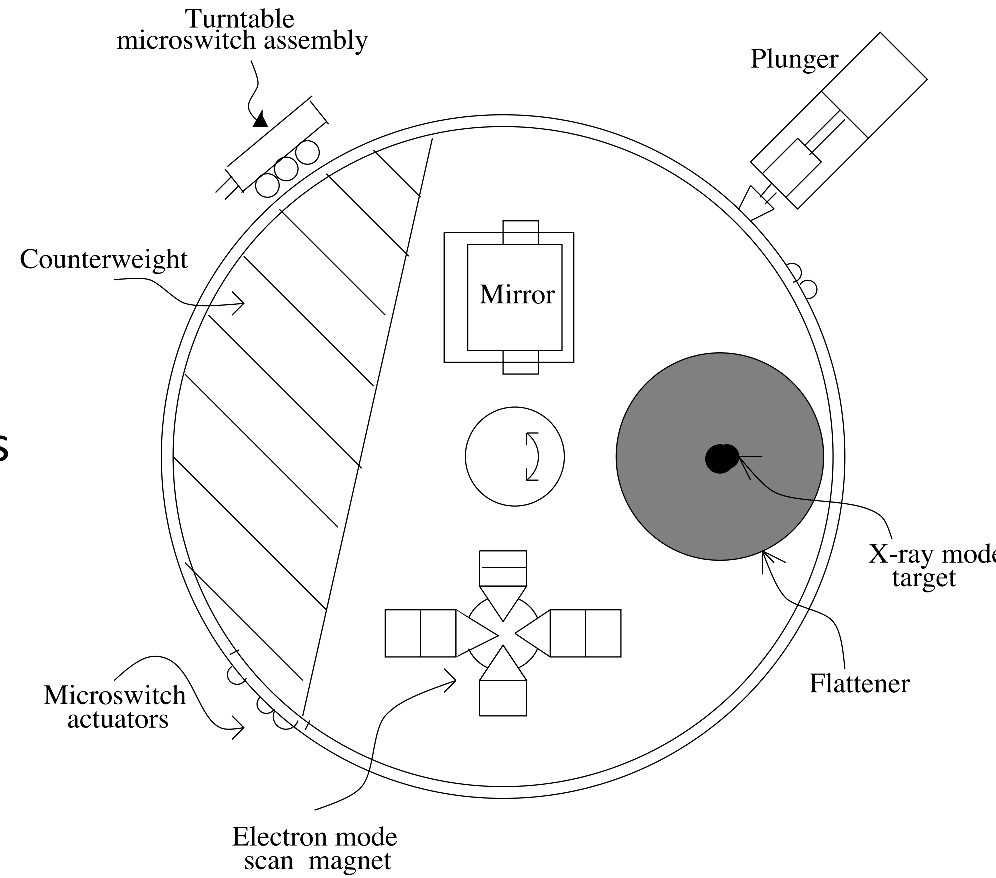
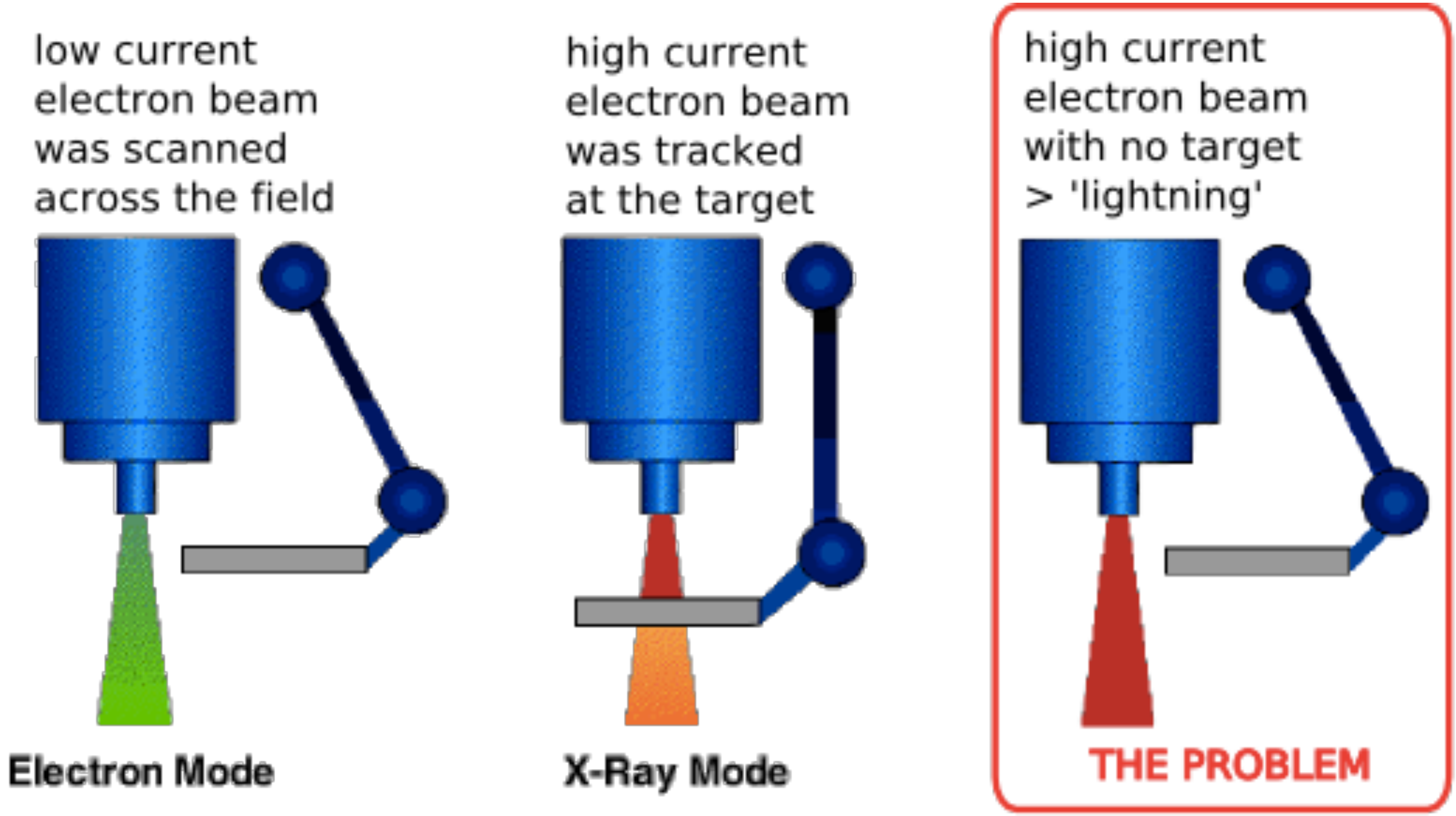


Figure 1: Upper turntable assembly.

Operation


low current electron beam was scanned across the field
high current electron beam was tracked at the target
high current electron beam with no target > 'lightning'
Electron Mode
X-Ray Mode
THE PROBLEM

Operation

Two failure modes:

1) Treatment suspend
2) Treatment pause

PATIENT NAME	: TEST			
TREATMENT MODE	: FIX	BEAM TYPE: X	ENERGY (MeV): 25	

	ACTUAL	PRESCRIBED	
UNIT RATE/MINUTE	0	200	
MONITOR UNITS	50 50	200	
TIME (MIN)	0.27	1.00	
GANTRY ROTATION (DEG)	0.0	0	VERIFIED
COLLIMATOR ROTATION (DEG)	359.2	359	VERIFIED
COLLIMATOR X (CM)	14.2	14.3	VERIFIED
COLLIMATOR Y (CM)	27.2	27.3	VERIFIED
WEDGE NUMBER	1	1	VERIFIED
ACCESSORY NUMBER	0	0	VERIFIED

DATE	: 84-OCT-26	SYSTEM	: BEAM READY	OP. MODE	: TREAT	AUTO
TIME	: 12:55: 8	TREAT	: TREAT PAUSE		X-RAY	173777
OPR ID	: T25V02-R03	REASON	: OPERATOR	COMMAND:		

Figure 2: Operator interface screen layout.

* Role of the Software

The Context

- Radiation therapy
  - Many people with cancer were diagnosed and treated, but were also exposed more radiation than they needed

The Context

- 11 installed machines (5 US; 6 Canada); 6 major accidents; 3 deaths
  - Improper scanning of the spread of the radiology beam, causing radiation burn and secondary cancer
- Machine recalled in 1987
- Denial – manufacturer and operation refused to believe that the system could make a mistake

* Story of Roy Cox

- Received proton beam instead of electron beam
- Died from severe radiation burns

- A Philadelphia hospital gave the wrong radiation dose to more than 90 patients with prostate cancer — and then kept quiet about it.
- A Florida hospital disclosed that 77 brain cancer patients had received 50 percent more radiation than prescribed because one of the most powerful — and supposedly precise — linear accelerators had been programmed incorrectly for nearly a year.

What Went Wrong: Gap in End Users' Understanding

- When the computer kept crashing, the medical physicist, did not realize that her instructions had not been saved.
- Software errors showing dose was not delivered, technician failed to verify
- * Another therapist failed to catch the error; errors were cryptic numbers.

What Went Wrong: Infrastructural Gaps

- It was customary — though not mandatory — that the physicist would run a test before the first treatment to make sure that the computer had been programmed correctly. But the hospital had a staffing shortage.

What Went Wrong: Issues in the Design of Therac-25

- AECL focused on fixing individual bugs not testing the whole system
  - Manufacturer would not believe that machine could fail
- System not designed to be fail-safe
  - Industry standards not followed
  - No proper hardware was installed to catch safety glitches
- No devices to report overdoses
- AECL did not communicate fully with customers
- Lack of communication and organization between hospitals, government and manufacturer

What Went Wrong: A Lack of Fault Tolerance

- One therapist mistakenly programmed the computer for “wedge out” rather than “wedge in,” as the plan required.
- And the physics staff repeatedly failed to notice it during their weekly checks of treatment records.

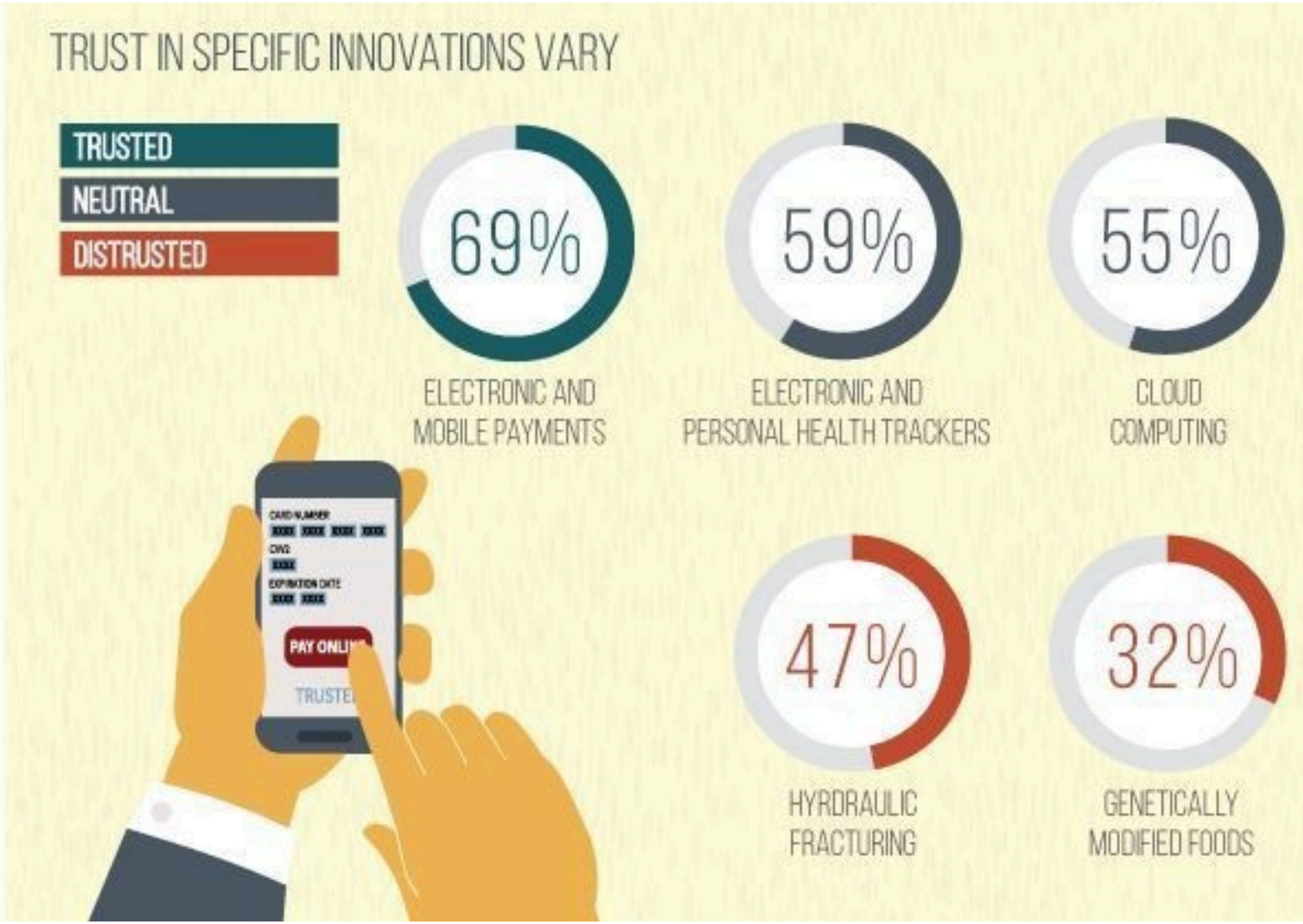
Dr. Howard I. Amols, chief of clinical physics at Memorial Sloan-Kettering Cancer Center in New York: “Linear accelerators and treatment planning are enormously more complex than 20 years ago. But hospitals are often too trusting of the new computer systems and software, relying on them as if they had been tested over time, when in fact they have not.”

Computerization of Radiation Technology

- Computerization reduced human time needed to calibrate machines and perform safety checks
- But human intervention was still needed to check whether the technology's software came up with a good treatment solution for a patient
- Not Forgetting the Human!

Global Agenda | Davos 2016 | Hyperconnectivity

Have we placed too much trust in technology?


TRUST IN SPECIFIC INNOVATIONS VARY
TRUSTED
NEUTRAL
DISTRUSTED
69%
ELECTRONIC AND MOBILE PAYMENTS
59%
ELECTRONIC AND PERSONAL HEALTH TRACKERS
55%
CLOUD COMPUTING
47%
HYRDRAULIC FRACTURING
32%
GENETICALLY MODIFIED FOODS

Why Detection is Difficult

- Identifying radiation injuries can be difficult.
- Organ damage and radiation-induced cancer might not surface for years or decades, while underdosing is difficult to detect because there is no injury.
- For these reasons, radiation mishaps seldom result in lawsuits, a barometer of potential problems within an industry.
- Under-reporting of “accidents”

People involved in the tragedies

- Company who made the softwares for the accelerometers
- Programmers and testers behind the softwares
- Doctors who prescribed medication
- Staff and technicians who managed the accelerometers
- ** Think about it for your recitation section!

Post Mortem

- Software lessons
  - Difficult to debug programs with concurrent tasks
  - Design must be as simple as possible
  - Documentation crucial
  - Code reuse does not always lead to higher quality

Solution?

“Mistakes are a fact of life. It is the response to the error that counts.”

- American writer and educator Nikki Giovanni

Solution: * Incident Learning System

- Don’t just monitor, learn from mistakes
  - “Blame culture” should give way to “Learn culture!”
- A well-designed incident learning system in a radiotherapy program consists of several steps
  - occurrence of incidents,
  - their identification and response,
  - reporting,
  - investigation,
  - causal analysis,
  - corrective actions,
  - Learning
- All included in a cyclic feedback loop
- A nationwide public mandatory reporting system

Solution: Defensive Design

- Designing for when things go wrong.
- Defensive design is the practice of anticipating all possible ways that an end-user could misuse a device, and designing the device so as to make such misuse impossible, or to minimize the negative consequences.

Lesson Learned

- This case study makes us reflect seriously on the need for a regulation of minimum quality in software development as in other fields.
- Although most of the software applications that are developed are applications without major importance, critical software is also being developed, such as the one installed in airports, airplanes, cars, sanitary machinery, elevators, etc.
- With no minimum software quality, the final outcome can be dramatic.

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Towards a consensus around standards for smartphone apps and digital mental health

John Torous, Gerhard Andersson, Andrew Bertagnoli, Helen Christensen, Pim Cuijpers, Joseph Firth, Adam Haim, Honor Hsin, Chris Hollis, Shôn Lewis ... See all authors

First published: 02 January 2019 | https://doi.org/10.1002/wps.20592 |

H. Hsin is an employee of Verily Life Sciences. The views expressed here are those of the authors and do not represent official views of Verily Life Sciences.

Mental disorders impact one in four people worldwide, yet access to care is challenging for those who suffer from them1. Mental health apps offer the potential to overcome access barriers for the nearly three billion people projected to own a smartphone by 2020.

London (CNN Business) — Google (GOOGL) says it has developed an artificial intelligence system that can detect the presence of breast cancer more accurately than doctors.

A study that tested the accuracy of the system, which was developed through a collaboration between the tech giant and cancer researchers, was published Wednesday in the scientific journal Nature.

Related Article: How AI came to rule our lives over the last decade

The program was trained to detect cancer using tens of thousands of mammograms from women in the United Kingdom and the United States, and early research shows it can produce more accurate detection than human radiologists.

According to the study, using the AI technology resulted in fewer false positives, where test results suggest cancer is present when it isn't, and false negatives, where an existing cancer goes undetected.

Thread

Vinay Prasad
@VPrasadMDMPH

Now back to this idea of biopsies that don't exist.

The other big problem with AI of diagnostic imaging is retrospective validation does not account for the fact that prospective deployment may change the way data is collected

4:00 PM · Jan 2, 2020 · Twitter Web App

9 Retweets **162** Likes

Vinay Prasad @VPrasadMDMPH · Jan 2
Replying to @VPrasadMDMPH
There may be biopsies that AI would have encouraged that do not exist, and we don't know the results of tests that were not done.