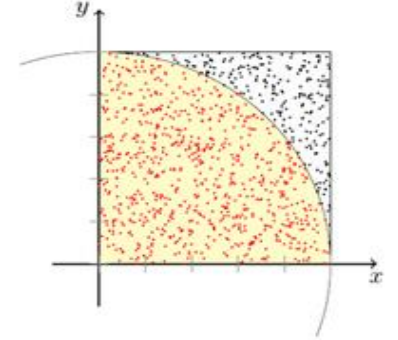# The History of the Monte Carlo Methods

Hamed Jafari

Research Division of Computer Graphics

Institute of Visual Computing & Human-Centered Technology
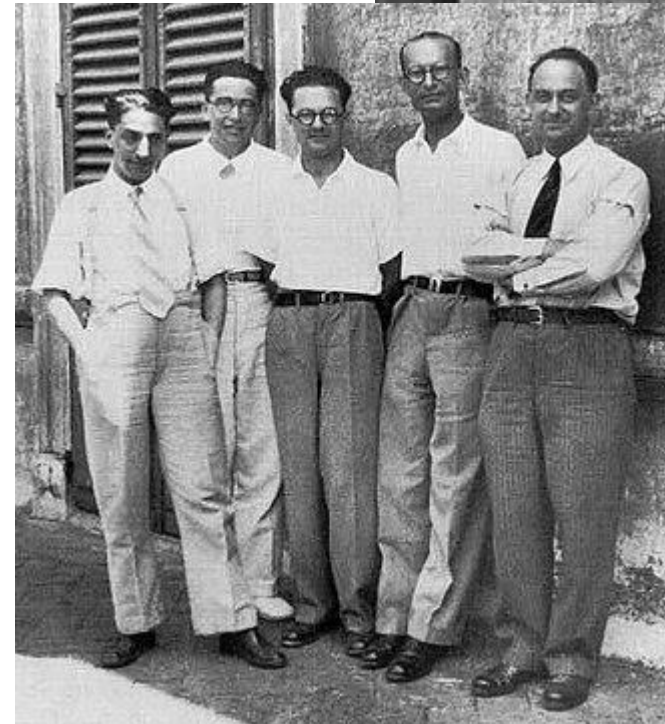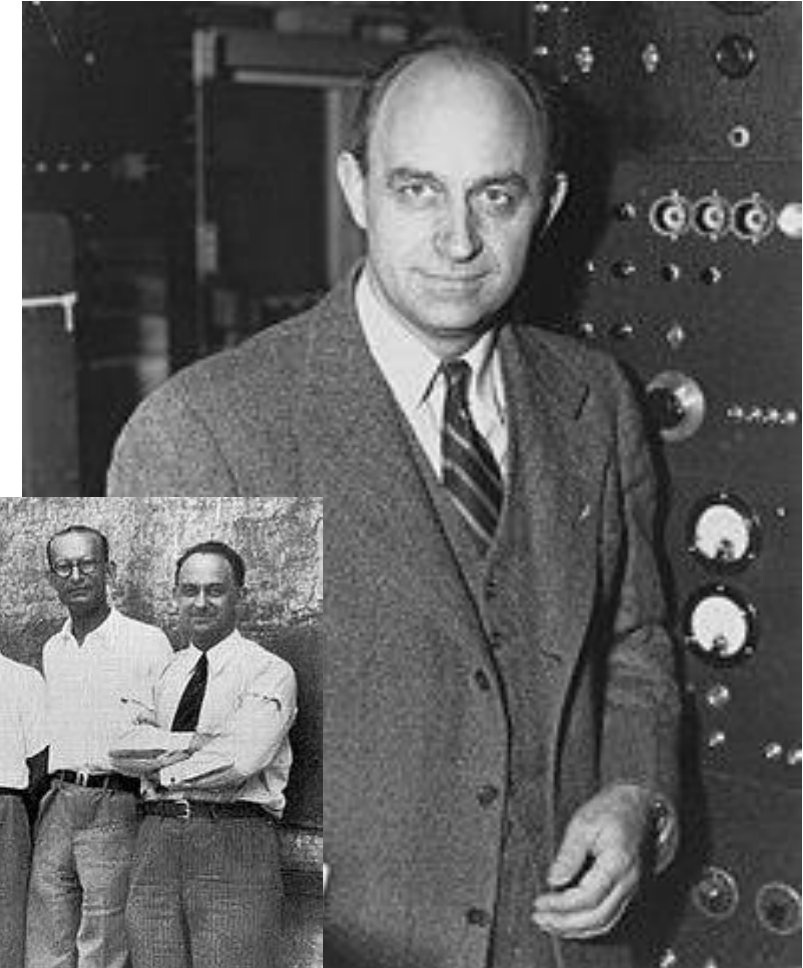
TU Wien, Austria

$$\hat{I} = \frac{1}{N} \sum_{i=0}^{N} \frac{f(x_i)}{p(x_i)}$$

1930s: Enrico Fermi

- Italian Physicist (1901-1954)

- „Architect of nuclear age"

- Creator of world's 1st reactor

- Developed the idea of statistical sampling

- Left Italy and became a scientist on the Manhattan Project at Los Alamos in New Mexico

- The idea of the first digital Computer by John Mauchly and Presper Eckert

- At University of Pennsylvania

- They Proposed the idea of electronic computer to Ballistic Research Lab in Aberdeen

- Lead to "Project PX"
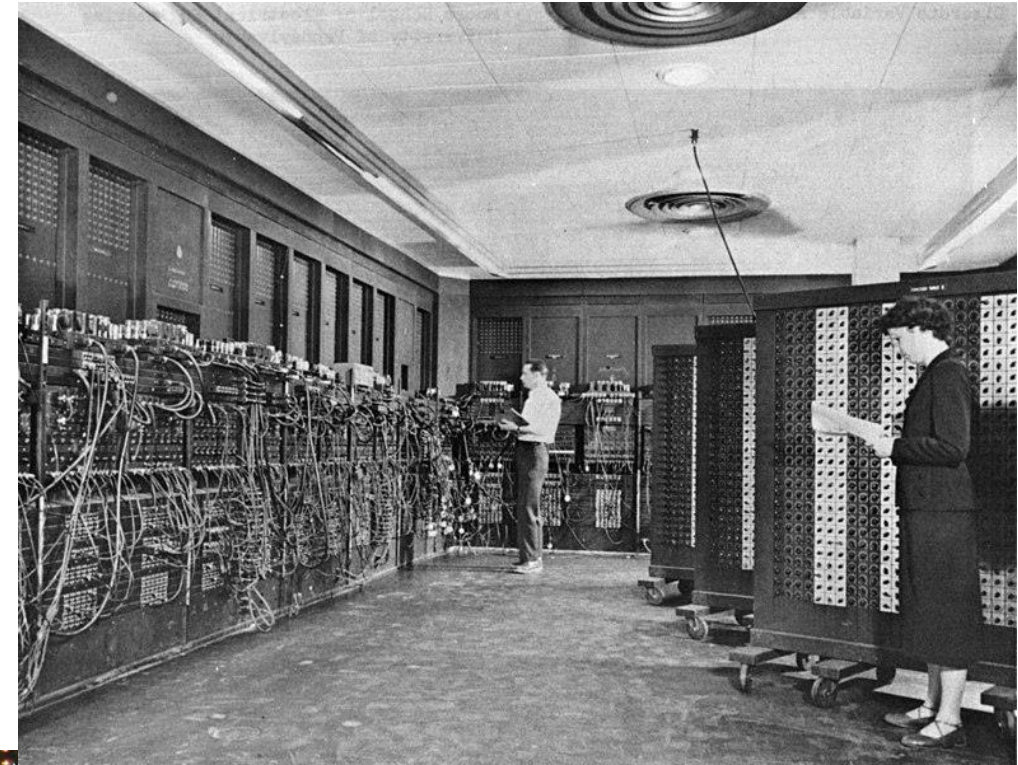

Presper Eckert (center)

- The first programmable, electronic, general-purpose digital computer

- Electronic Numerical Integrator and Computer

- 27 tons, 167 square meters, 18000 vacuum tubes

- Completed in 1946 – operational from 1947 until 1955

- First review tests were firing table problems for Aberdeen

vacuum tubes

function tables

John von Neumann
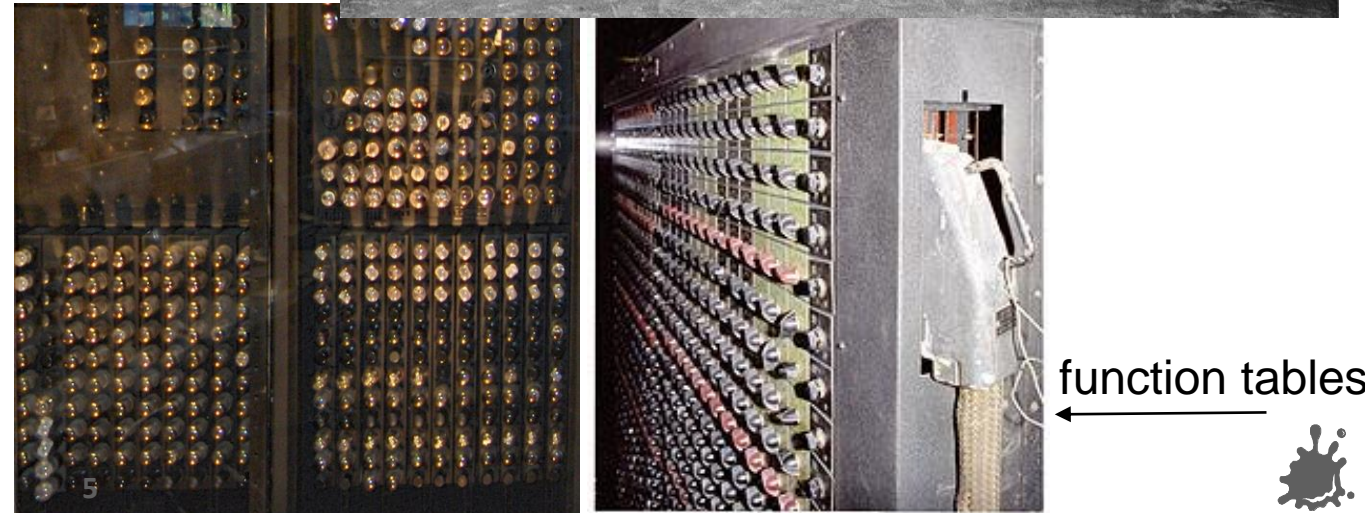
- Hungarian-American mathematician, computer scientist and physicist.

- 1903-1957

- 1940s: Consultant to both Los Alamos and Aberdeen

- That connection lead to his involvement with ENIAC

- Greek-American physicist (1915-1999)

- Was also working at Los Alamos

- Known for Metropolis-Hasting algorithm and as one of the creators of MANIAC

The ENIAC
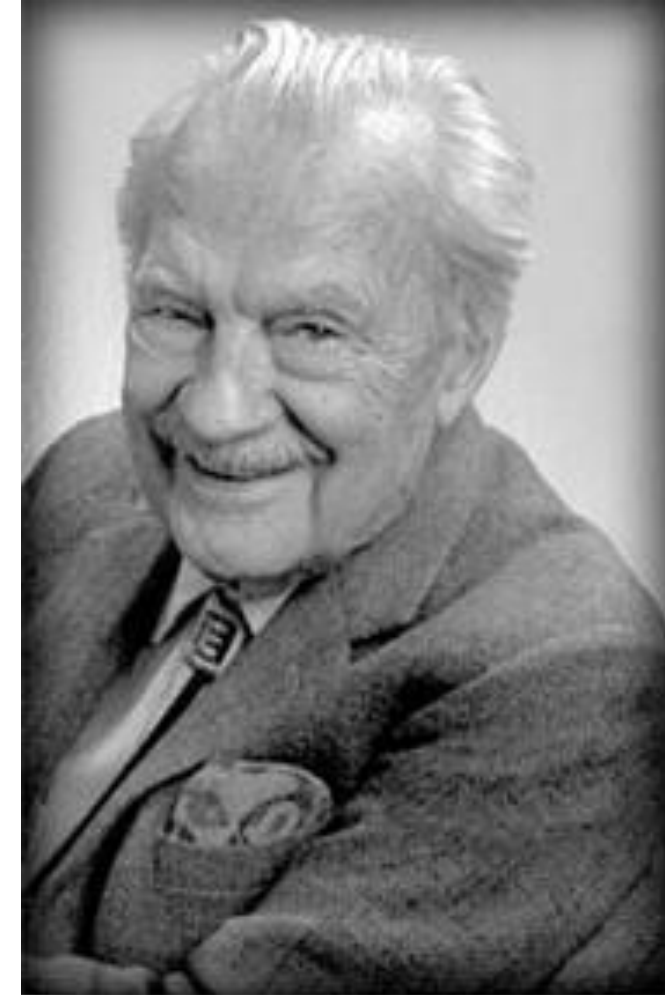
- ENIAC was completed in 1946 and unveiled to the world

- The Review was held in the spring

- Metropolis also presented his results

Stanislaw Ulam

- Polish-American Mathematician (1909-1984)

- Another scientist at Los Alamos during war

- Was among the attendees at the review of ENIAC results

- Very interested in random processes (and random games!)

- His intuition lead to the resurrection of statistical approaches

Birth of Monte Carlo

- Von Neumann proposed a method based on Ulam's idea in 1947

- The method was named "Monte Carlo" because of Ulam's uncle, who liked to borrow money "to go to monte-carlo"

- "Middle-Square Digits" were used as pseudo-random number generator

- Shutdown 1946 and moved in 1947: 2 years absence of ENIAC

- Enrico Fermi was then working at Los Alamos

- Fermi invented FERMIAC, the Monte Carlo trolley
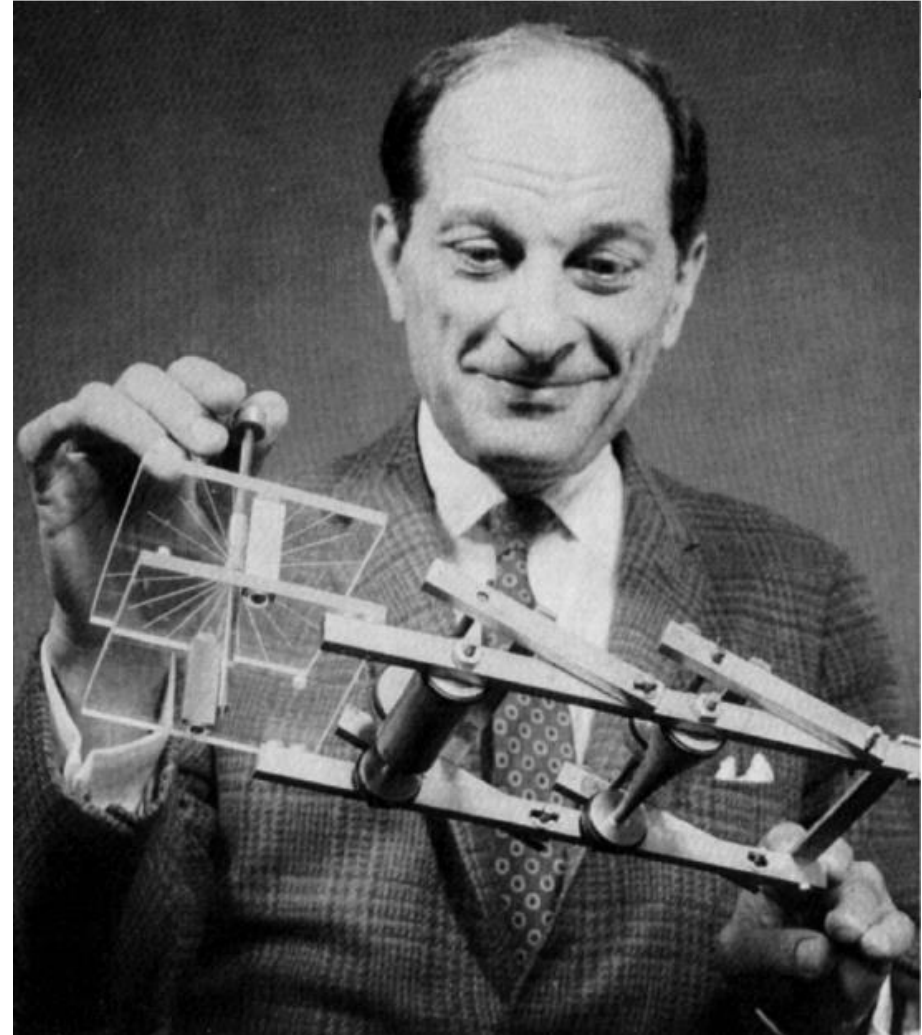
Stan Ulam and the FERMIAC

- Arrived in Aberdeen in 1947

- First Monte Carlo problems were tested in 9 different configurations with favourable results

- Monte Carlo was here to stay…

- Monte Carlo went on to be named one of the top 10 algorithms of 20th century.

- "Given the digital computer's reputation for deterministic calculation, it's fitting that one of its earliest applications was the generation of random numbers." – Barry Cipra – SIAM news May 2000

- Operational 1952-1965

- ***M**athematical **A**nalyzer **N**umerical **I**ntegrator and **A**utomatic **C**omputer Model*

- Design directed by Nicholas Metropolis

- MANIAC II and III were also built in 1957 and 1964

- More statistical tests
  - Markov Chain Monte Carlo

Markov Chain

Metropolis-Hasting Algorithm
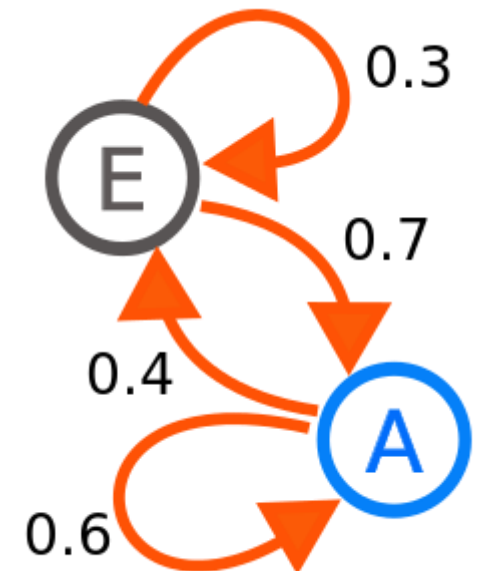
- A Markov Chain Monte Carlo Method

- First published in 1953

- Hasting published the general form in 1970

- Goal is to find a sampling distribution proportional to the base function

- Iteratively find the next sample on the chain based on a proposal-acceptance scheme

Metropolis Light Transport

- By Eric Veach in 1997

- Application of Metropolis-Hasting for rendering equation

- First Attempt not relying on independent sampling for global illumination

- Distribution of sampled paths proportional to actual contribution in the image (Metropolis-Hasting)

- Local exploration by utilizing Markov Chains and applying mutation rules

References

- "The beginning of the Monte Carlo Method" – N. Metropolis

- Wikipedia

- The Best of the 20th Century: Editors Name Top 10 Algorithms – Barry Cipra, SIAM news volume 33, number 4

- Physically Based Rendering - Matt Pharr, Wenzel Jakob, and Greg Humphreys

- https://www.atomicheritage.org/history/computing-and-manhattan-project