INTERNATIONAL CONFERENCE ON MODELLING SIMULATION and COMPLEX SYSTEMS,
Obafemi Awolowo University, Ile-Ife

Modeling, Simulation and Complex Systems for National development

By
Professor Clement Onime
(onime@ictp.it)
ICTP,
Trieste, Italy

Contents

- Introduction
  - International Centre for Theoretical Physics (ICTP)
- National development
  - Challenges for Scientific research
  - Artificial Intelligence: from Machine Learning to Generative A.I.
- Conclusion

INTRODUCTION

The Abdus Salam International Centre for Theoretical Physics

Academic Profile

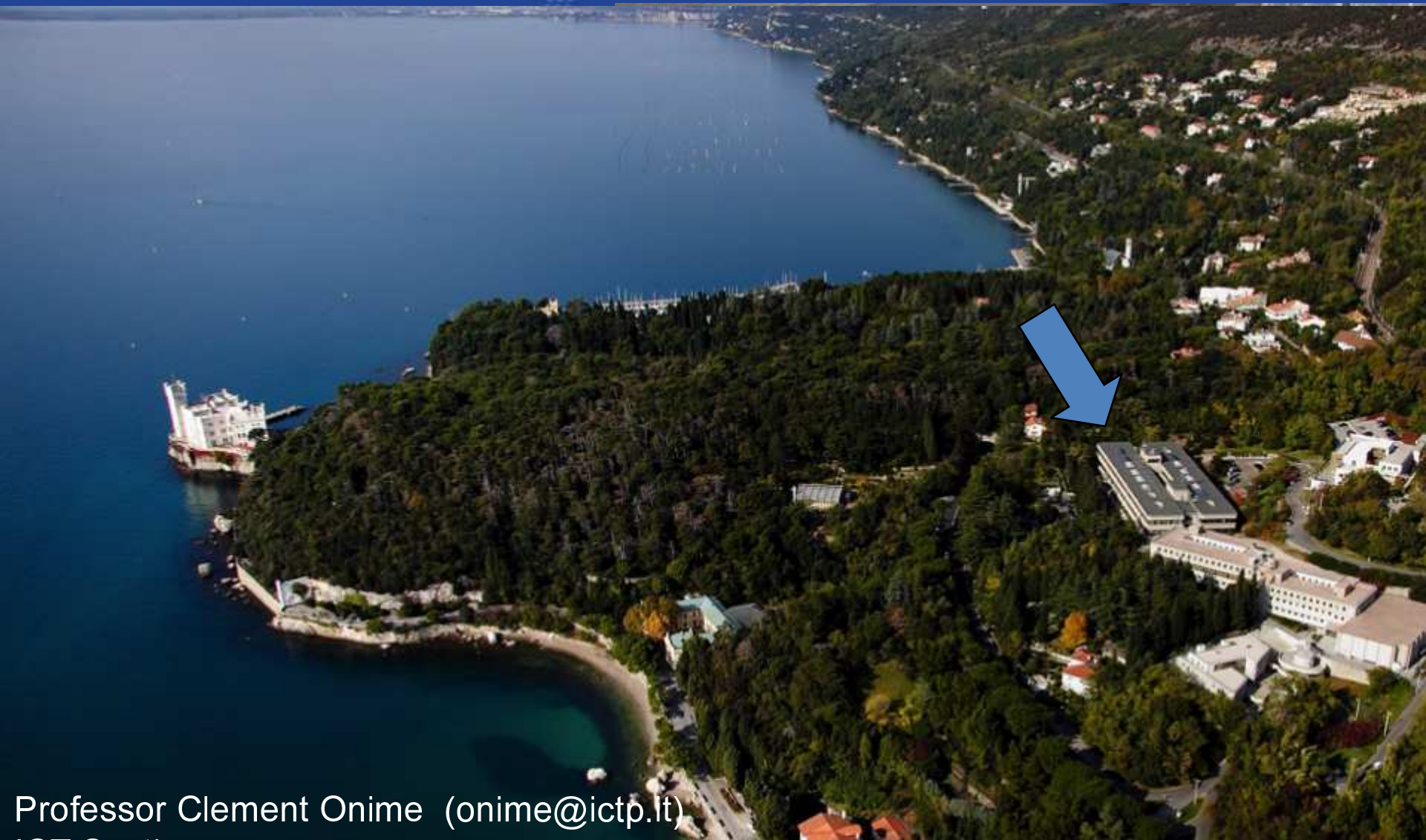
- Professor of Computer Science, Computer Engineering and Computational Science
- Co-supervise PhD and MSc students from institutions in U.K, Canada, Mexico, Nigeria, Ethiopia and Italy
- *Scientific output* and Other contributions
  - Scientific publications
  - e-learning framework
  - INTERNET gateway
  - Development of HPC centres

Research

- Mixed Augmented Virtual Reality Laboratory (MARVLab), UK.
- International Research Team on Data Science, Machine Learning, & Artificial Intelligence.
- High Performance and Super Computing
- Cloud Computing (infrastructure models, trust and security)
- member of IEEE and ACM
- Promoting multidisciplinary research around computing

Biometric Technology, Internet of Things, Data Science, Big Data Analytics, Artificial Intelligence, Mobile Computing, Computer Networking, Information Systems, Internet resources & services, Green Computing, Engineering education: e-learning+ virtual and remote labs, mathematical modeling for engineering and radio/satellite and digital communications systems.

The Abdus Salam
International Centre
for Theoretical Physics



Professor Clement Onime (onime@ictp.it)

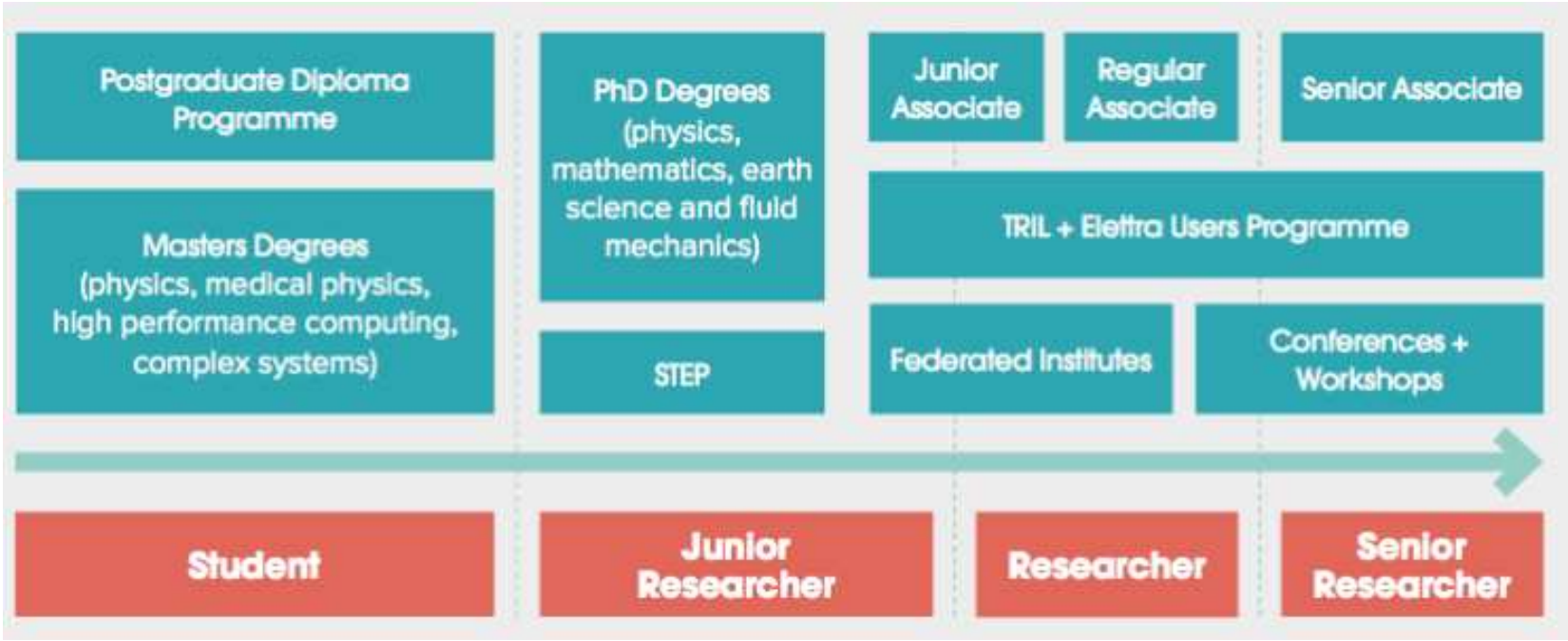
What is ICTP?

- Founded in 1964 by Nobel Laureate Abdus Salam to enhance international cooperation through science
- Combines world class research with a unique global mission of building science capacity in the developing world
- Governed by tripartite agreement between Italy, UNESCO and IAEA

Key areas: Research, Education and Outreach

Training at ICTP

ICTP training programmes: Supporting scientists in all stages of their careers



For more details see https://www.ictp.it/

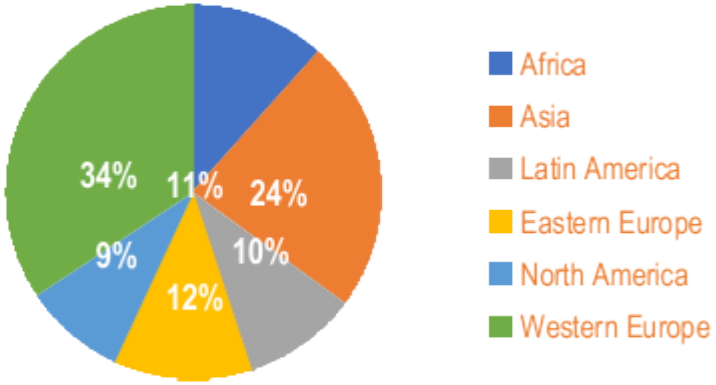
Training at ICTP

ICTP's international conferences encourage "Brain Gain"

- Provide training and skills to scientists from developing countries
- Organise more than 60 conferences/workshops each year
- Welcome up to 5000 scientists from 145 nations each year
- Attract an additional 1000-2000 scientists/year through hosted activities

ICTP visiting scientists: where do they come from?

- More than 170,000 visits since 1970
- 188 countries represented
- In 2020, 27% of ICTP visiting scientists were women



ICTP global Impact

ICTP regional centres of excellence

Mexico:

The Meso-American Institute for Sciences (MAIS) was established in collaboration with the Universidad Autónoma de Chiapas (UNACH) as a regional headquarters of ICTP in Mexico, Central America and the Caribbean.

Brazil:

The ICTP South American Institute for Fundamental Research (ICTP-SAIFR), is a regional centre for theoretical physics created in collaboration with the State University of Sao Paulo (UNESP) and the Sao Paulo Research Funding Agency (FAPESP).

Rwanda:

Inaugurated in 2018, the East African Institute of Fundamental Research (EAIFR), based at the University of Rwanda's Kigali campus, offers an important educational and research hub for the region and for Africa.

China:

In Beijing, the International Center for Theoretical Physics-Asia Pacific (ICTP-AP) is hosted at the University of the Chinese Academy of Sciences (UCAS) and provides opportunities for advanced training, research and education in theoretical physics and related interdisciplinary areas.

ICTP	ICTP Partner Institutes	04
S	ICTP Schools and Workshops	07
C	ICTP-OEA Affiliated Centres	11
N	ICTP-OEA Networks	07
M	ICTP-OEA Scientific Meetings	11

ICTP Testimonials

David Gross, Nobel Laureate in Physics 2004 and Director, Kavli Institute for Theoretical Physics:

"Much good emanates from ICTP. Salam's vision of a facility that couples the doing of first-rate research with advanced scientific training has been overwhelmingly vindicated and validated."

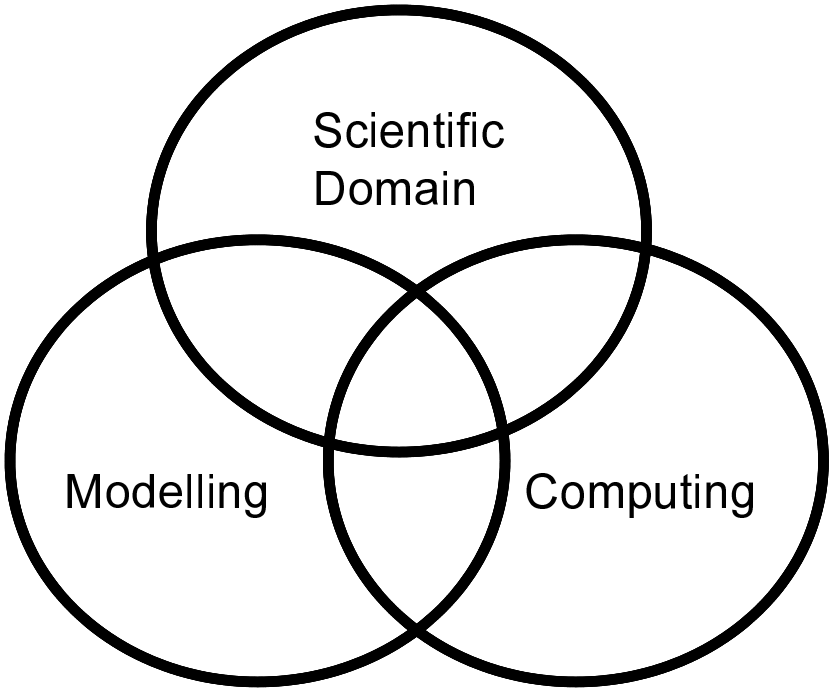
ICTP Testimonials

Stephen Hawking,
University of Cambridge:

"Over the years, ICTP has left a deep legacy in performing and promoting outstanding fundamental scientific research. In particular, it has had a major impact supporting science in developing countries."

NATIONAL DEVELOPMENT

Scientific research



- Scientific research is benefiting from the intersection of
  - Scientific (domain) processes
  - Applied mathematics (modelling & numerical analysis)
  - **Computing** (hardware, algorithms, scaling, performance and Artificial Intelligence)

Addressing national challenges requires scaling problem size and complexities

Some challenges

- All recent global advances (sceintific discoveries) in the last 20 years have been powered by the use of computational results.
- Some of these came about through the modeling and simulation of complex systems.
- Two key challenges for Science are size and complexity
- How can we as scientists address
  - increasingly bigger problems?
  - increasingly complex problems and domains?

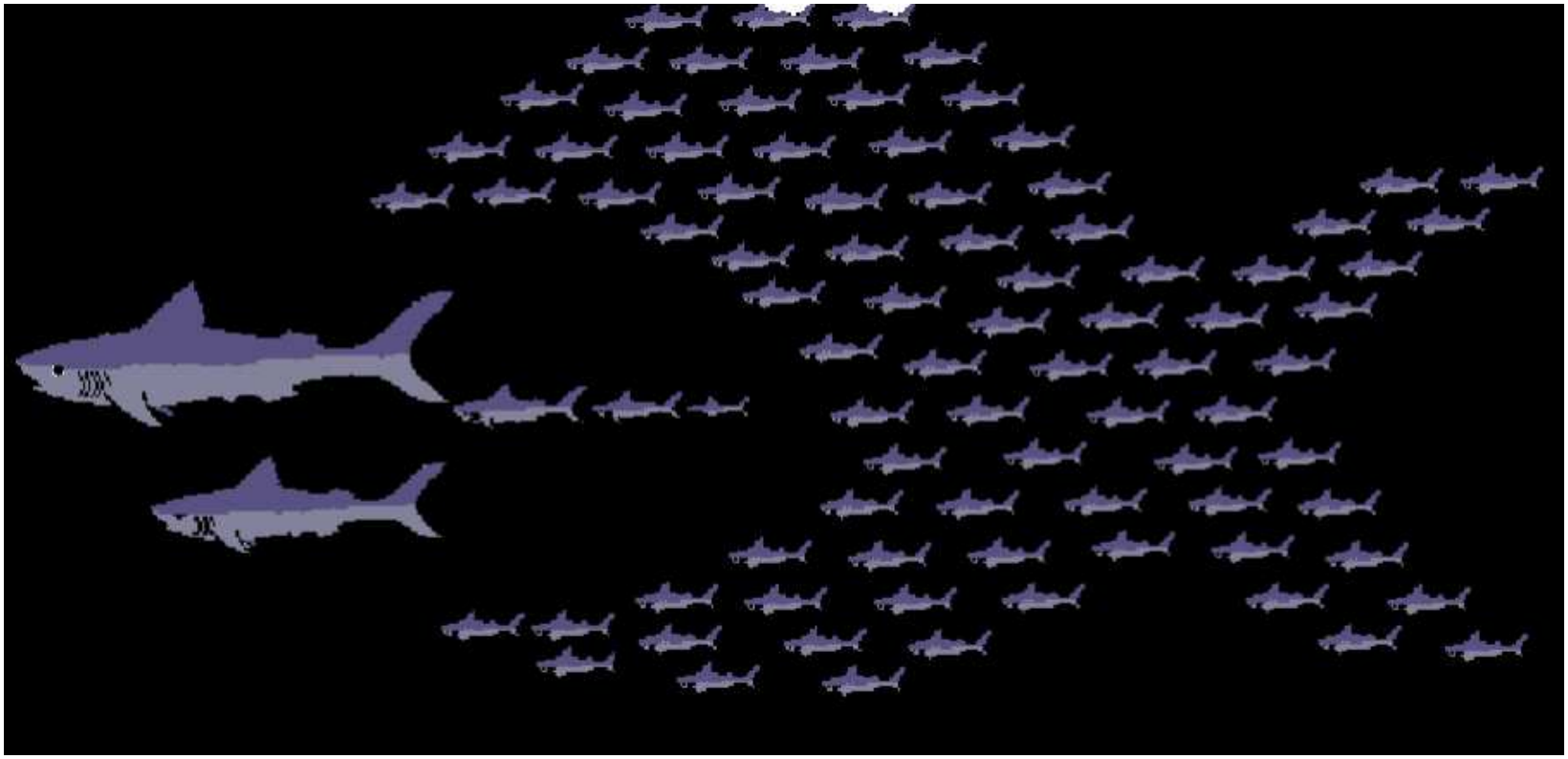
Solution is not bigger computers

Cray T3E

A 1480-processor T3E-1200 was the first **supercomputer** to achieve a performance of more than 1 teraflops running a computational science application, in 1998

Your single cellphone is more powerful than the above super-computer, harnessing collective computing power is key

Making small computers effective



High Performance Computing derived mainly from quantity
Complexity can be addressed by divide-and-conquer applied to task, data and algorithms..

Example: Cluster of Desktops

Each Desktop computer had 1 AMD Athlon (single-core) CPU with 256MB ram

Example of General Purpose Graphics Processing Unit (GPGPU)

- Nvidia Tesla K40M
  - Frequency of 915MHz
  - 2880 processing cores
  - 12GB Internal memory
  - Interface standard: PCI Express 3.0x16
  - Power Consumption: 235W
  - 1.43 Tflops (peak, DP)
  - 4.29 Tflops (peak, SP)

Exascale computing

Item	Size in computing	Commercial size
Kilobyte	$2^{10} = 1024$	$10^3 = 1000$
Megabyte	$2^{20} = 1024^2 = 1{,}048{,}576$	$10^6 = 1{,}000{,}000$
Gigabyte	$2^{30} = 1024^3 = 1{,}073{,}741{,}824$	$10^9 = 1{,}000{,}000{,}000$
Terabyte	$2^{40} = 1024^4 = 1.09951162778e+12$	$10^{12} = 1{,}000{,}000{,}000{,}000$
Petabyte	$2^{50} = 1024^5 = 1.12589990684 \times 10^{15}$	10^{15}
Exabyte	**$2^{60} = 1024^6 = 1.15292150461 \times 10^{18}$**	**10^{18}**
Yottabyte	$2^{70} = 1024^7 = 1.18059162072 \times 10^{21}$	10^{21}
Zettabyte	$2^{80} = 1024^8 = 1.20892581961 \times 10^{24}$	10^{24}

Exaflop = 1 million trillion = 1 million million million computations / second

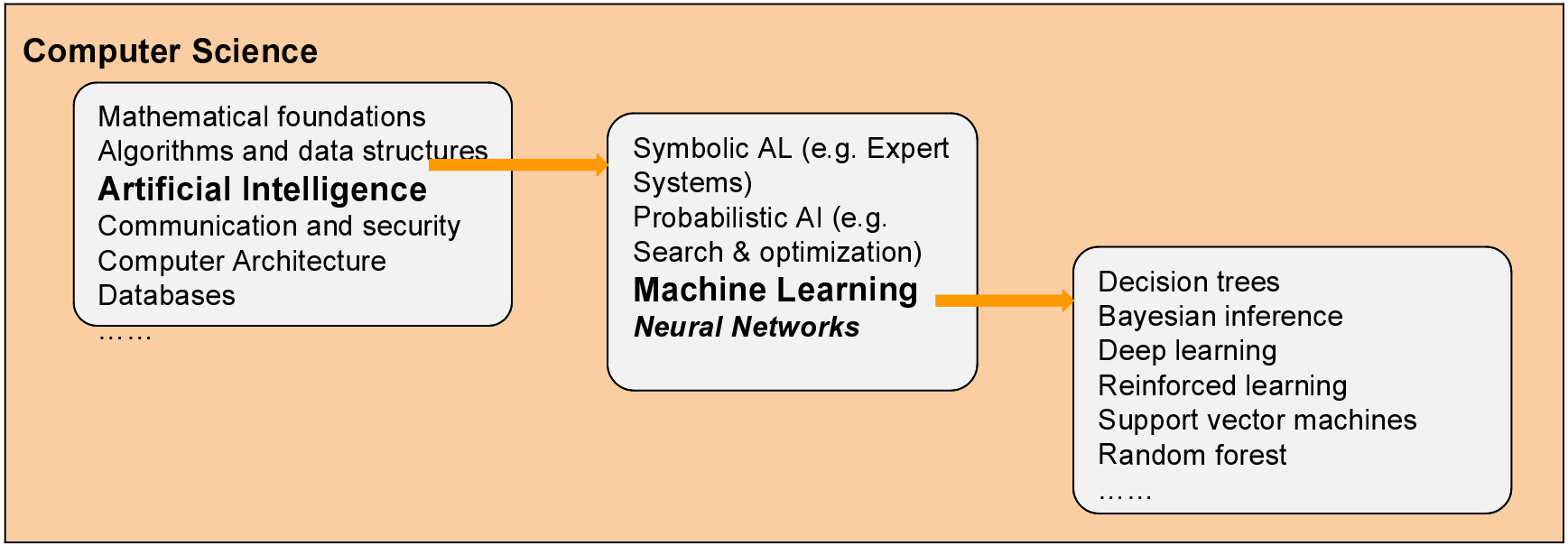
Artificial Intelligence

- Example - Excelling at playing the game of chess

Symbolic AI	Mathematical/Statistical AI	Machine Learning Approach
"Let us sit down with the world's best chess player and put his/her knowledge into a computer program"	*"Let us simulate all the different possible moves and the associated outcomes at each single step and go with the most likely to win"*	**"Let us show millions of examples or real life and simulated games (won and lost) to the program, and let it learn from experience"**

From AI to ML

- Artificial Intelligence (AI) is a branch or Computer Science that uses algorithms and techniques to mimic human intelligence
- Machine Learning (ML) is one of several AI techniques for sophisticated cognitive tasks



Machine Learning paradigm

- Machine Learning is a particularly interesting technique because it represents a paradigm shift within AI

Traditional AI techniques

- **Static** – hard-coded set of steps and scenarios
- **Rule Based** – expert knowledge
- **No generalization** – handling special cases is difficult

Machine Learning

- **Dynamic** – evolves with data, finds new patterns
- **Data driven** – discovers knowledge
- **Generalization** – adapts to new situations and special cases

A.I and Deep Learning

(Neural Networks)

Techniques	Accuracy	Detection Rate (Precision)	False Alarm Rate
Support Vector Machine (SVM)	94.65%	85.45%	5.2%
Artificial Neural Networks (ANN)	99.71%	99.68%	0.12%
Bayesian Network	97.52%	97.04%	2.50%
K- Nearest Neighbour (KNN)	97.15%	96.84%	2.88%
Fuzzy Logic Based System	95.2%	86.84%	1.15%
Decision Trees	97.93%	98.52%	2.19%
Logistic Regression	94.7%	77.8%	2.9%

"A Comparative Analysis of Various Credit Card Fraud Detection Techniques" by Yashvi Jain, NamrataTiwari, ShripriyaDubey,Sarika Jain International Journal of Recent Technology and Engineering (IJRTE)ISSN: 2277-3878, Volume-7 Issue-5S2, January 2019

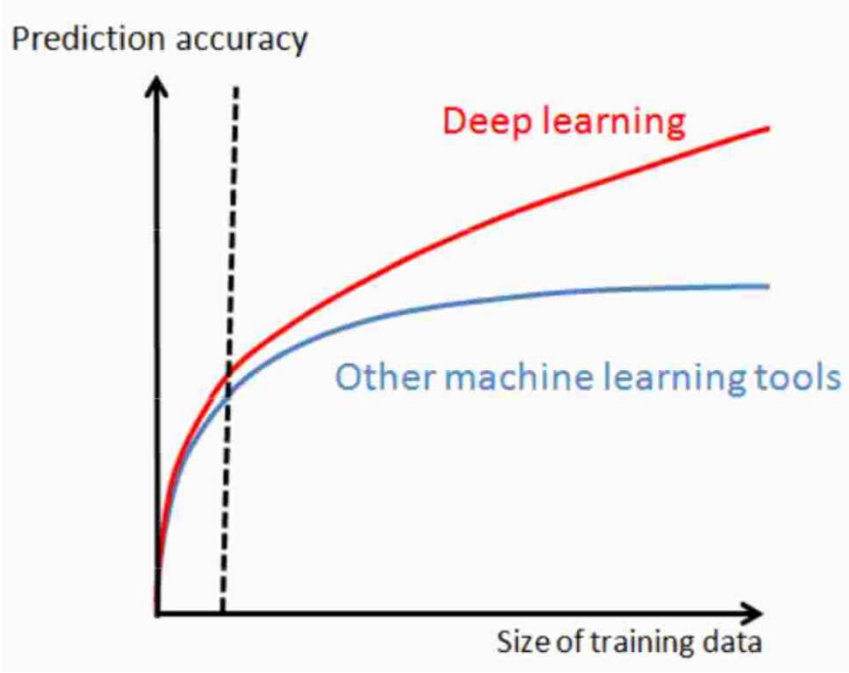
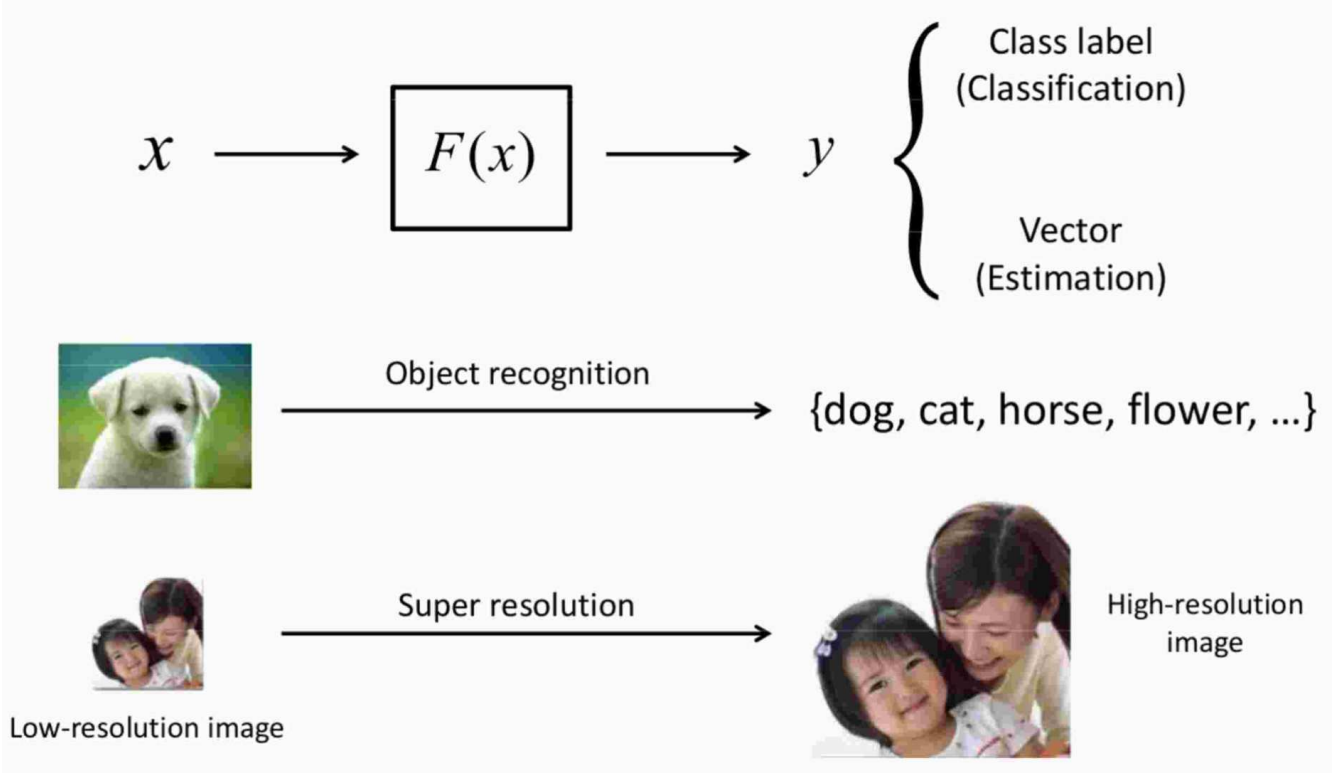


Image from "Deep Learning in Computer Vision" by Xiaogang Wang

Advances in A.I. applications



Trend is towards a blackbox approach:

Image from "Deep Learning in Computer Vision" by Xiaogang Wang

Generative A.I.

- Able to generate “new” content: images, videos, text, essays, audio, video, etc..
  - Must be trained
    - An A.I. model is only as good as it’s training data.

Conclusion

- Modeling and simulation is the bedrock of Scientific Computing and offers non-trivial opportunities for Education and National development.
- Harnessing the available computing power can help us simulate increasingly complex systems and address bigger complex problems.

Thank you!!!

The nation that outcomputes outcompetes

ICAWMSCS Conference in 5 minutes

- 2-day conference: Amalgamation of applied mathematics, scientific domains *(Physics*, *Chemistry*, *Engineering*, *Biology)* and computing.
- High number number of abstracts
  - Over 85% of submitted abstracts accepted
    - 10 minutes for each presenter
    - Some will be published
    - Upload your completed presentations via registration portal or https://dbox.ictp.it/index.php/s/ICAWMSCS-UPLOAD
  - Student Prices

- Next edition in 2025..