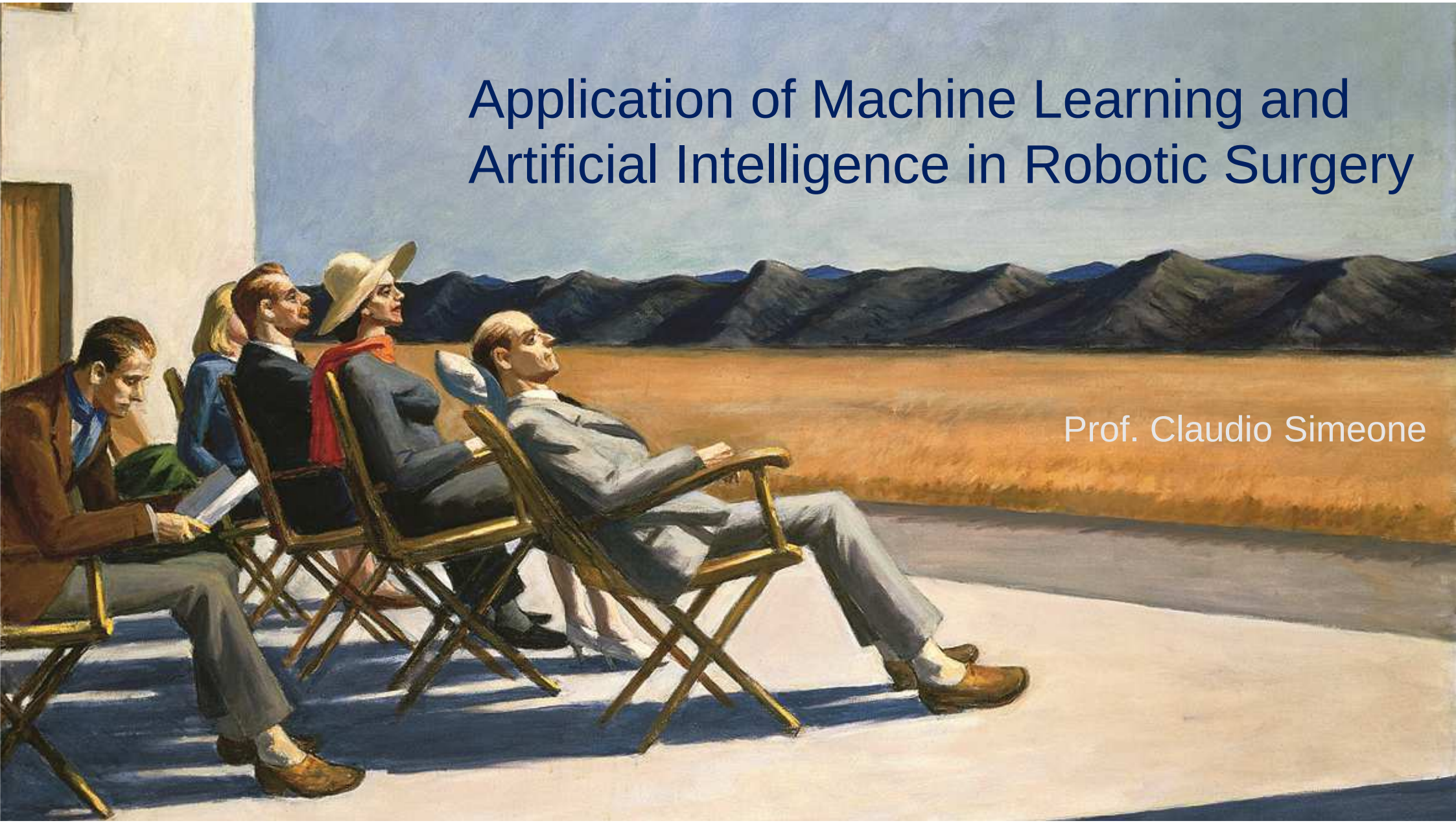
Application of Machine Learning and Artificial Intelligence in Robotic Surgery

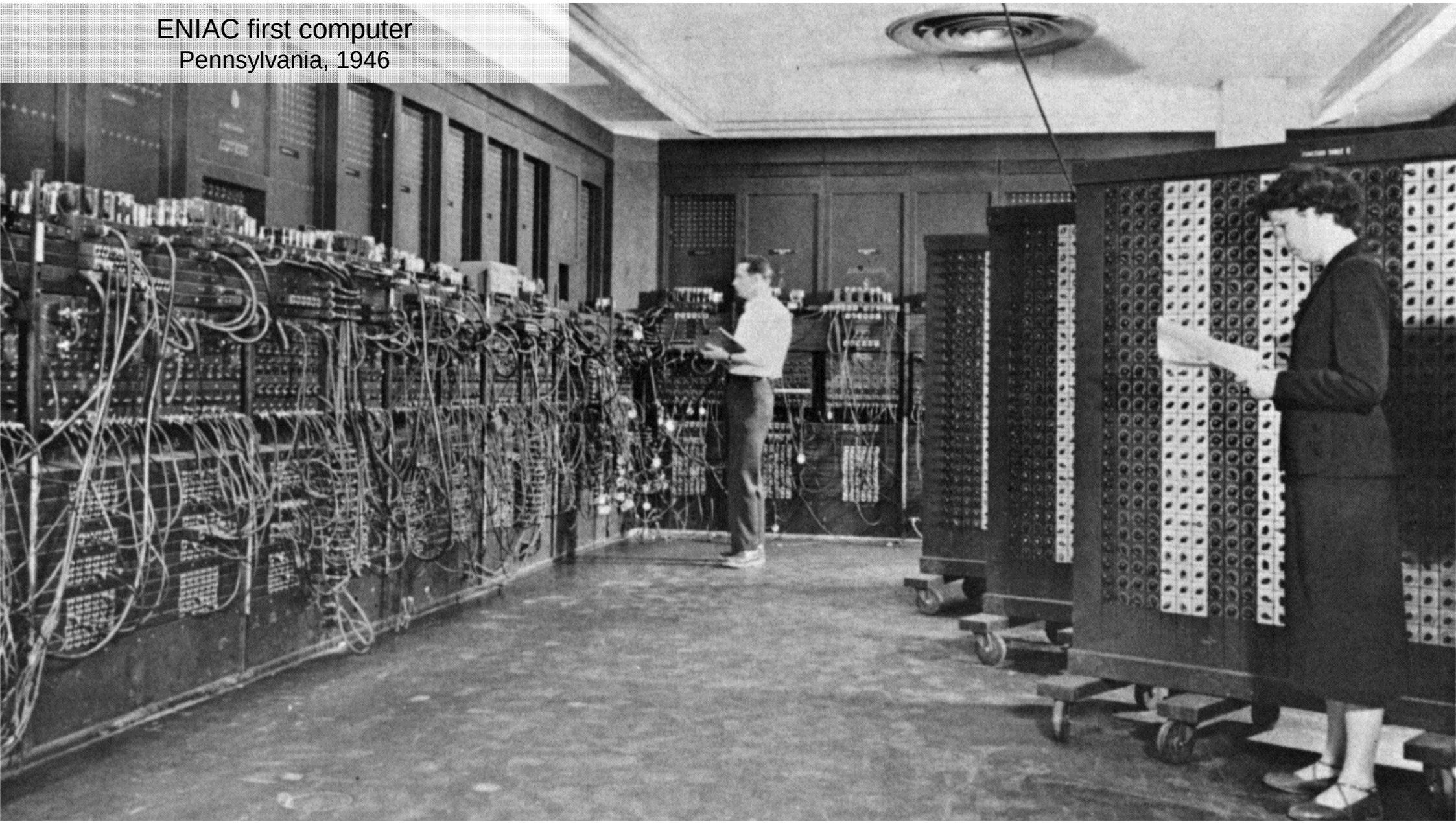


Prof. Claudio Simeone

Deep Blue vs Garry Kasparov

Philadelphia February 10, 1996

ENIAC first computer
Pennsylvania, 1946



First Apple smartphone

USA, June 2007

Google Driverless Car
California, 2018

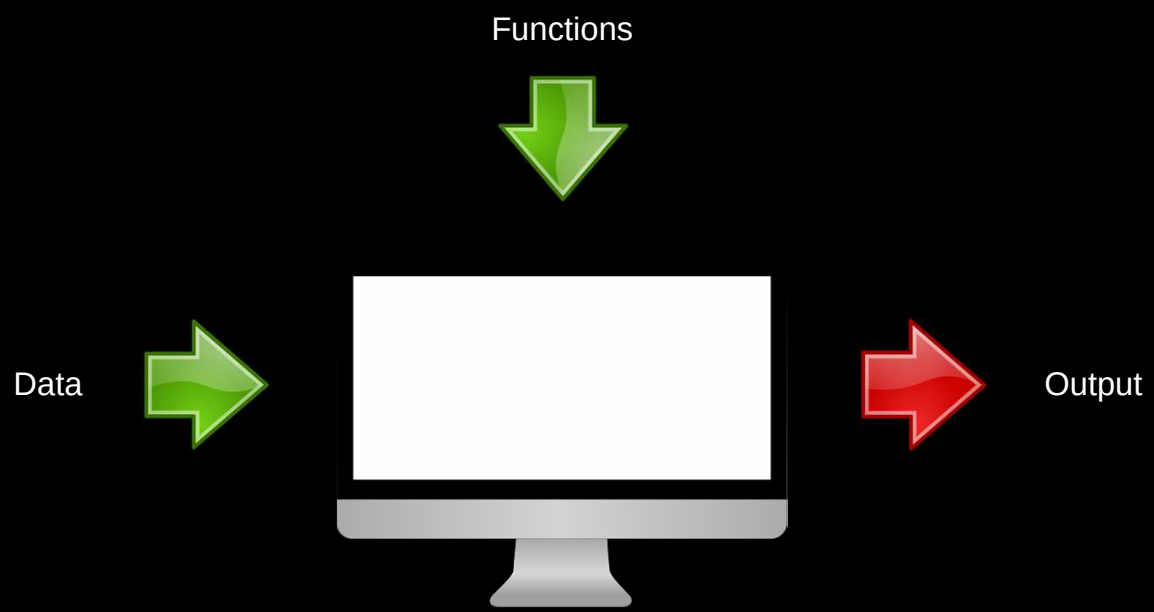
What is Machine Learning?

“FIELD OF STUDY
THAT GIVES COMPUTERS THE ABILITY TO
LEARN WITHOUT BEING EXPLICITLY
PROGRAMMED.”

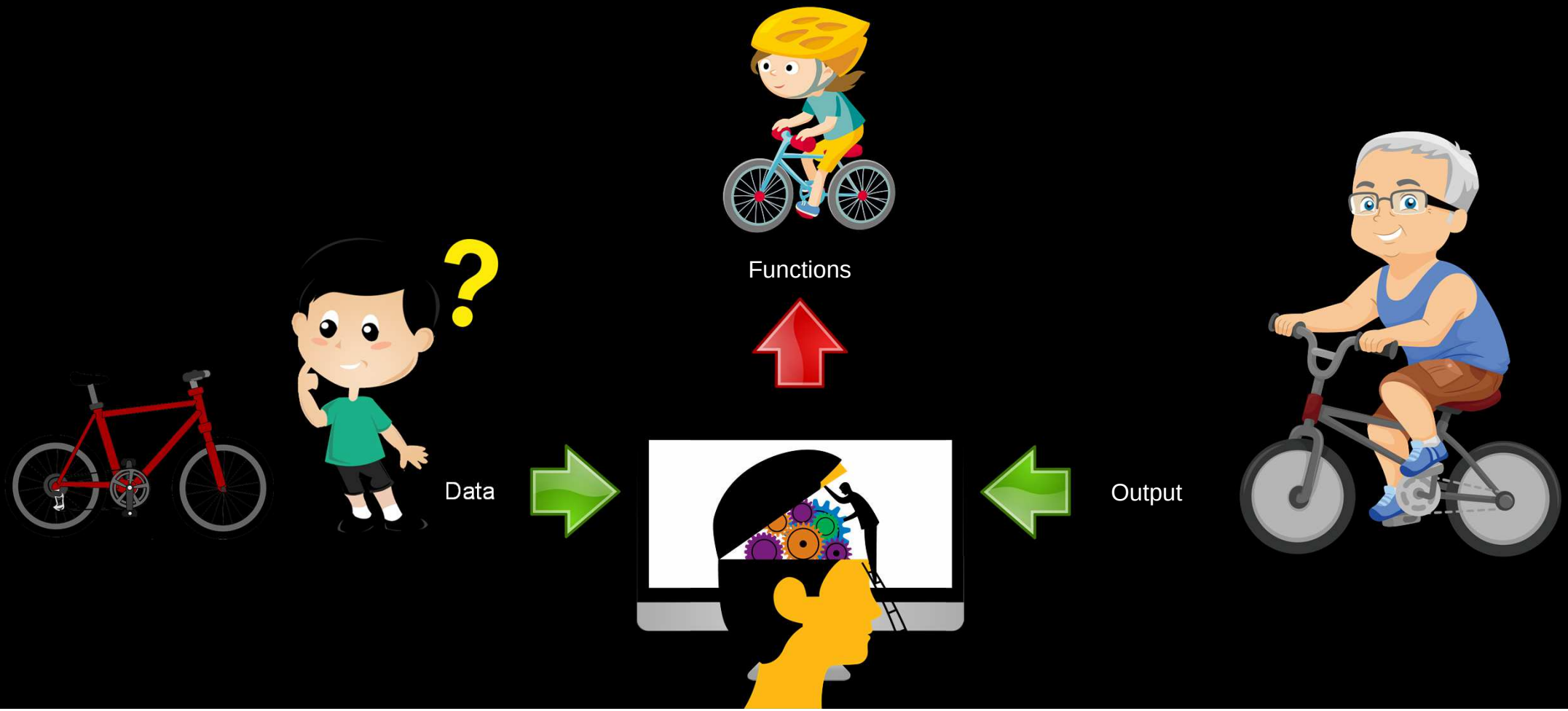
Arthur Samuel

Machine Learning

TRADITIONAL USE OF THE MACHINE



Human Learning & Machine Learning



How Machine Learning Works

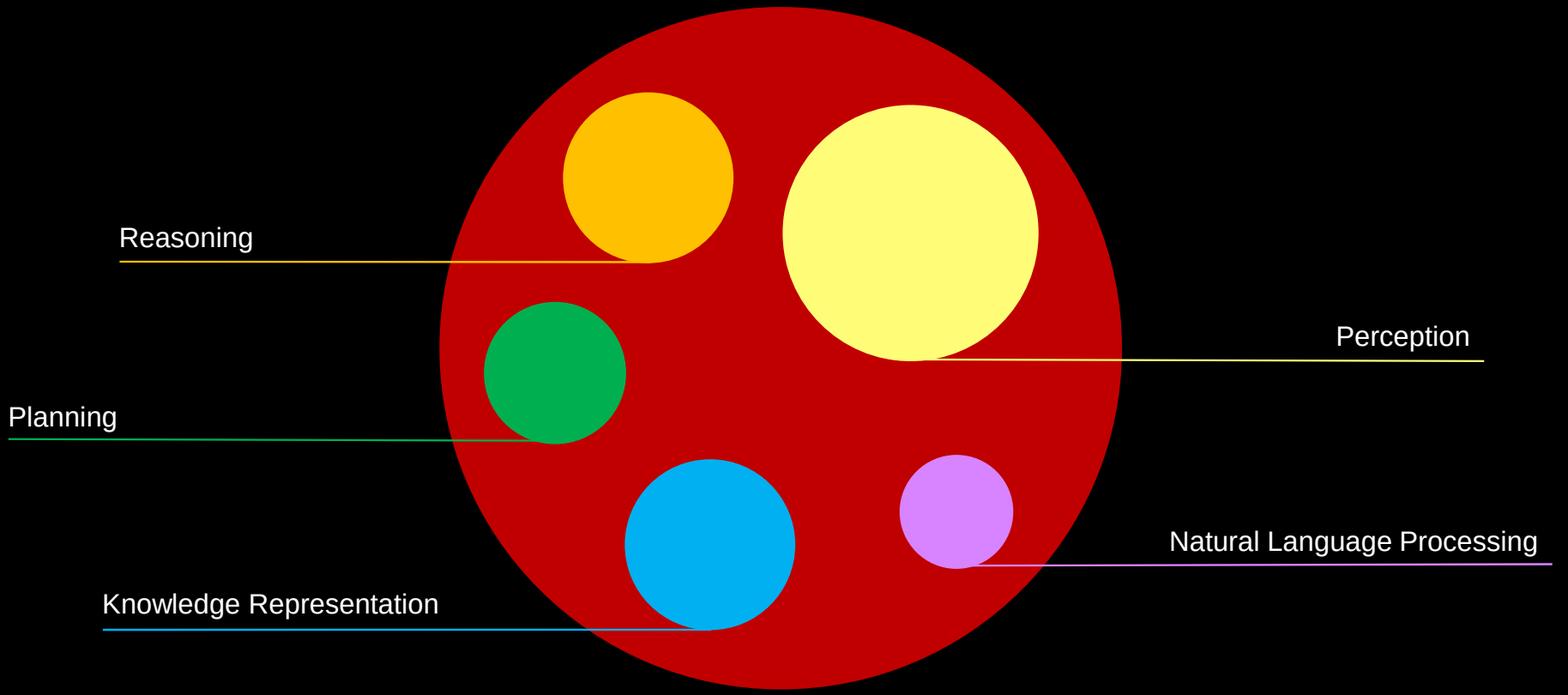
Big Data

Functions

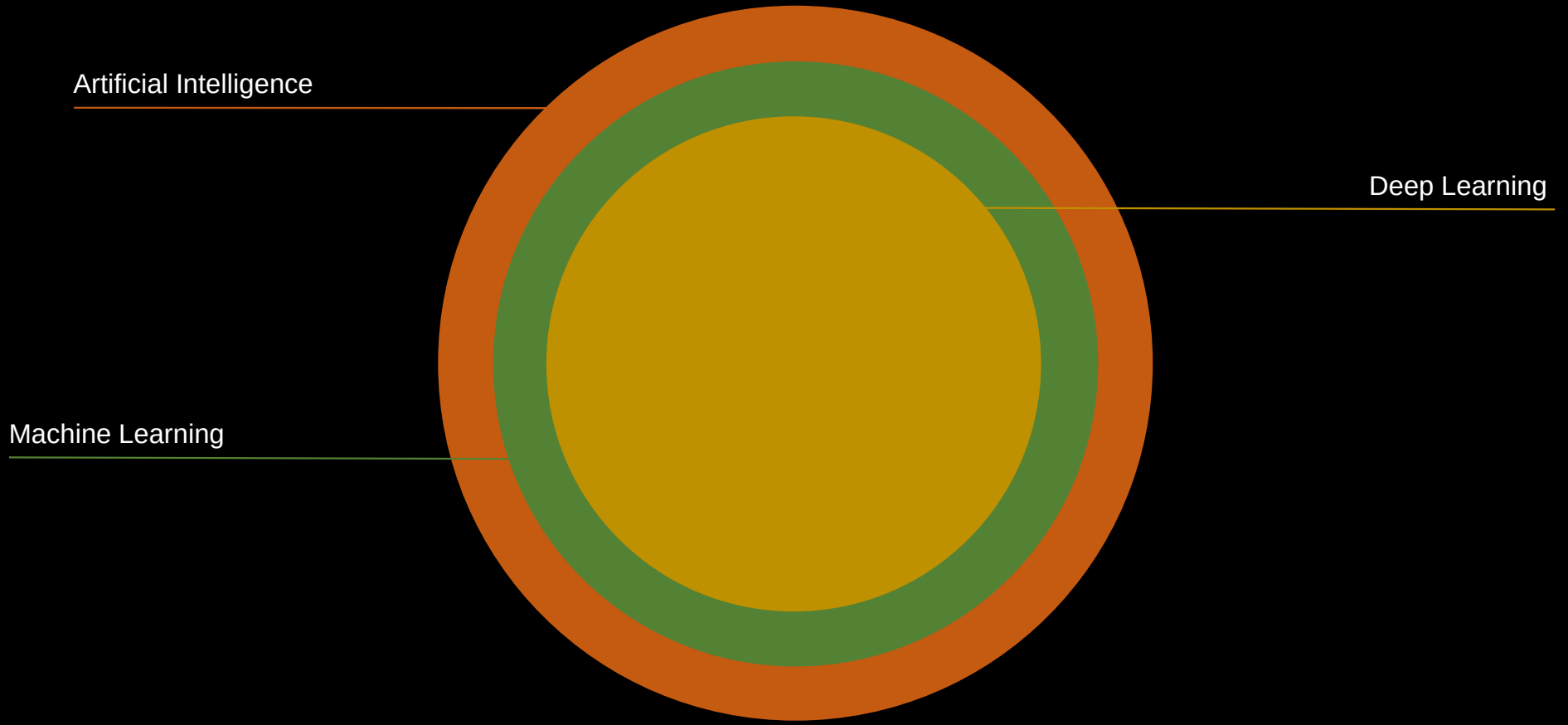
Matching

Goals

What is Artificial Intelligence?



Machine Learning & Deep Learning



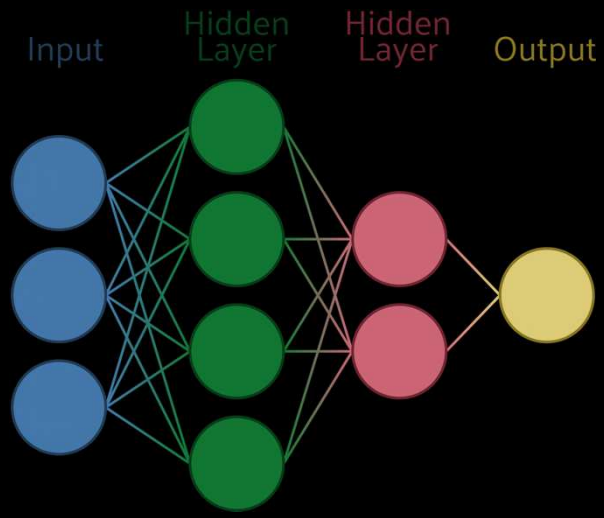
Deep Learning & Neural Networks

Neural networks are a series of algorithms that mimic the operations of a human brain to recognize relationships between vast amounts of data.

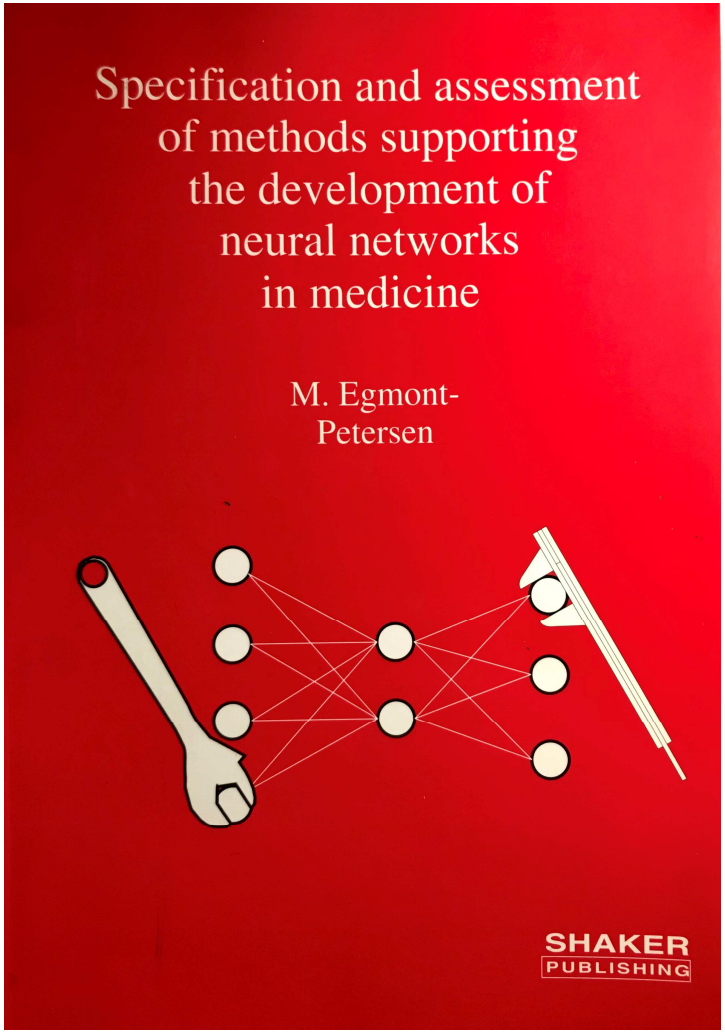
A “neuron” in a neural network is a mathematical function that collects and classifies information according to a specific architecture.

Deep Learning & Neural Networks

A neural network contains layers of interconnected nodes. Each node is a perceptron and is similar to a multiple linear regression.



In a multi-layered perceptron (MLP), perceptrons are arranged in interconnected layers. The input layer collects input patterns. The output layer has classifications or output signals to which input patterns may map.

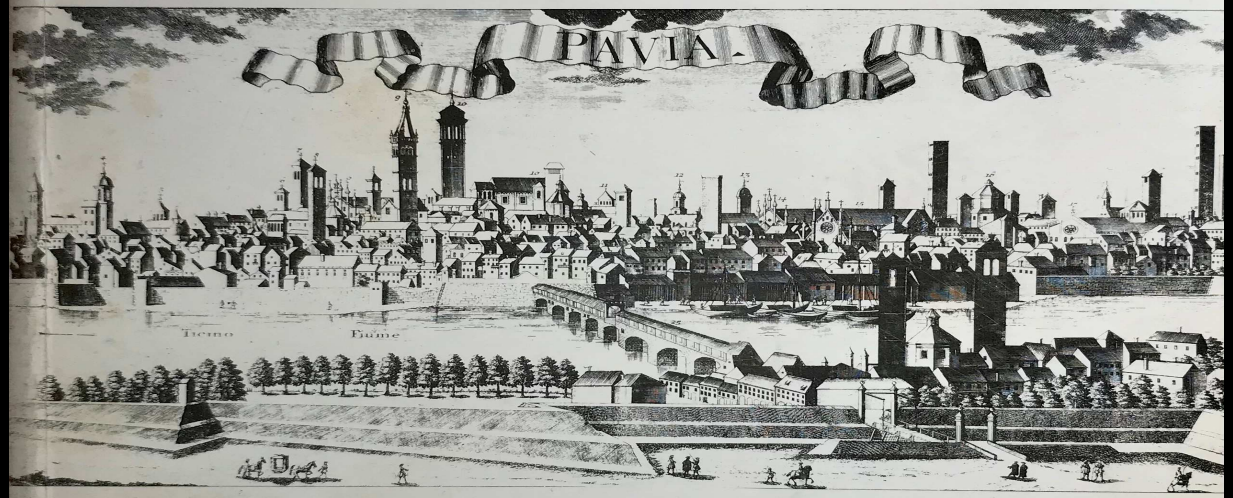

Specification and assessment
of methods supporting
the development of
neural networks
in medicine
M. Egmont-
Petersen
SHAKER
PUBLISHING

UNIVERSITY OF PAVIA
School of Urology
Department of Informatics

UNIVERSITY OF REIMS (CHU)
Department of Urology

I.R.C.S. POLICLINICO S. MATTEO

LOMBARDIA INFORMATICA S.p.A.



PROCEEDINGS

Supplemento straordinario ai «Seminari Pavesi di Urologia»

1st EUROPEAN CONFERENCE ON INFORMATICS TEACHING AND UROLOGY

PAVIA, ITALY, NOVEMBER 20-21 1989
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AI & Bladder Cancer

Eminaga et al. recently investigated the capability of AI to perform diagnostic classification of cystoscopy findings.

The authors trained 5 different AI platforms using a digital atlas of cystoscopy composed of 479 images covering 44 cystoscopic findings.

AI & Bladder Cancer

Muralidaran et al. published a work with the aim to build an AI able to diagnose urothelial cell carcinoma (UCC) in urine cytology smears based on data on morphometry, densitometry, and chromatin pattern.

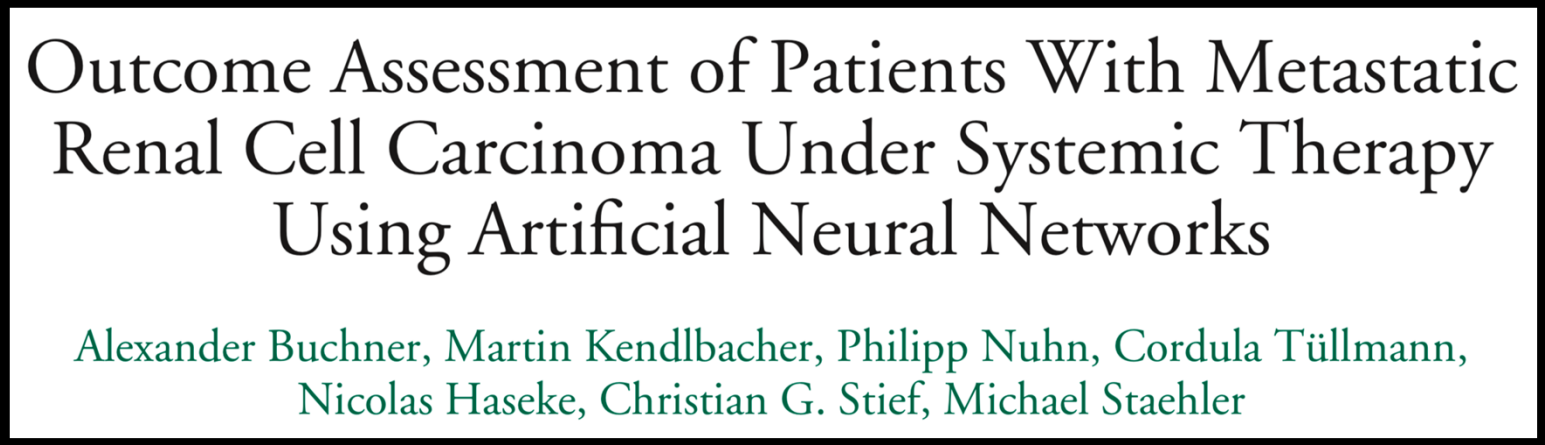
Artificial Neural Network in Diagnosis of Urothelial Cell Carcinoma in Urine Cytology

Chandrasekaran Muralidaran, M.B.B.S.,[1]
Pranab Dey, M.D., M.I.A.C., F.R.C.PATH,[2*] Raje Nijhawan, M.D.,[2]
and Nandita Kakkar, M.D.[3]

The authors trained their AI with 115 cytology samples, 59 of witch were pathological proven UCC.

AI & Kidney Cancer

Buchner et al. studied the capability of an AI to predict the outcome of patients with metastatic renal cell carcinoma (RCC) starting systemic therapy.


Outcome Assessment of Patients With Metastatic Renal Cell Carcinoma Under Systemic Therapy Using Artificial Neural Networks

Alexander Buchner, Martin Kendlbacher, Philipp Nuhn, Cordula Tüllmann, Nicolas Haseke, Christian G. Stief, Michael Staehler

They fed their AI with data of 175 patients, all underwent radical or partial nephrectomy of the primary tumor before systemic therapy.

AI & Prostate Cancer

In a pioneering study in 1994 *Snow et al.* investigated whether ANN would be helpful to predict biopsy results in men with abnormal PSA, as well as to predict treatment outcome after radical prostatectomy.

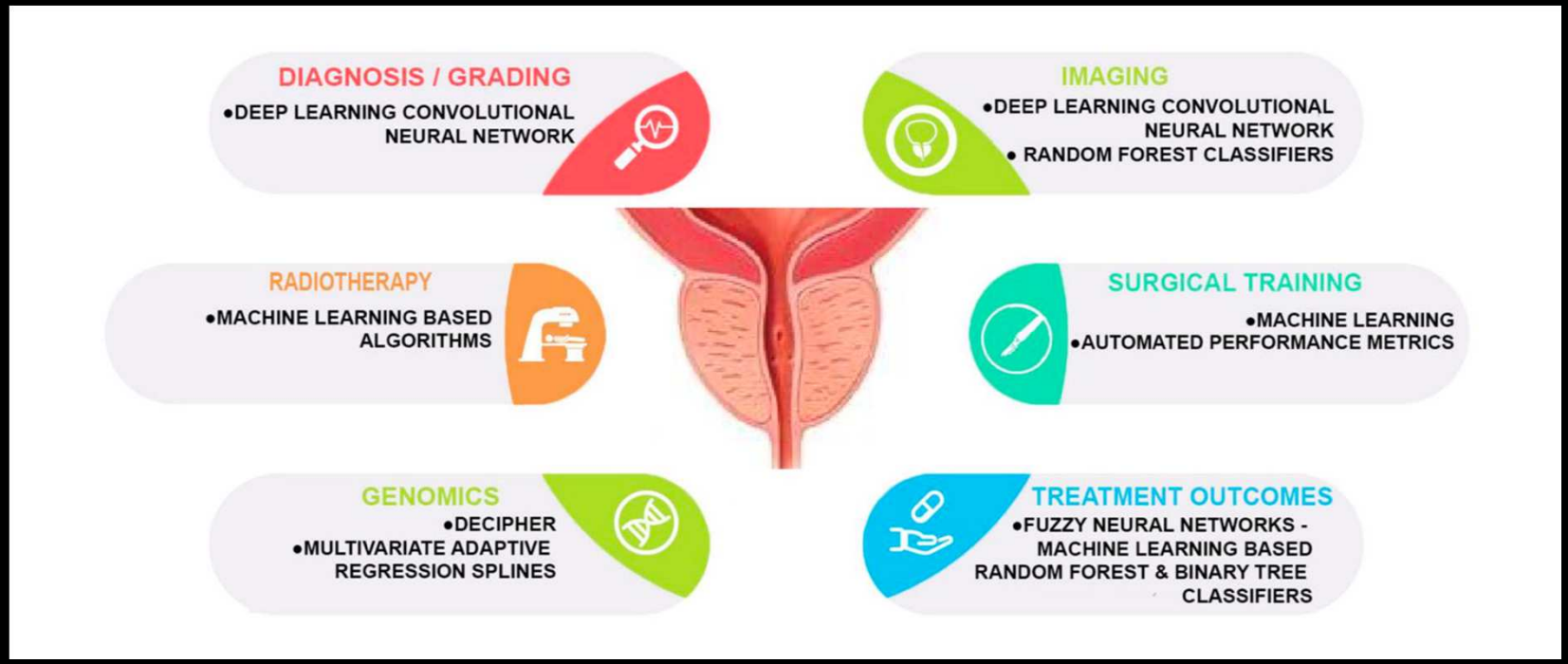
Prediction of prostate cancer by deep learning with multilayer artificial neural network

Takumi Takeuchi, MD[1]; Mami Hattori-Kato, MD[1]; Yumiko Okuno, MD[1]; Satoshi Iwai, MD[2]; Koji Mikami, MD[1]

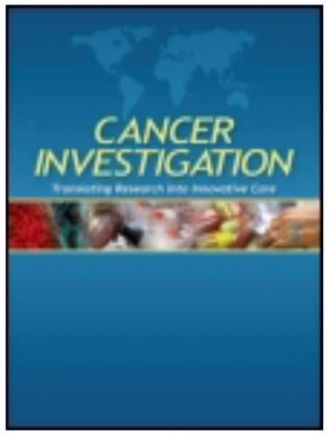
[1]Department of Urology, Japan Organization of Occupational Health and Safety, Kanto Rosai Hospital, Kawasaki, Japan; [2]Department of Medical Informatics and Economics, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan

More recently, *Takeuchi et al.* evaluated whether prostate cancer detection rate on prostate biopsy was predicted by deep learning using a multilayer AI.

AI & Prostate Cancer



Applications of artificial intelligence and its subfields in prostate cancer.



Taylor & Francis
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Cancer Investigation

ISSN: 0735-7907 (Print) 1532-4192 (Online) Journal homepage: https://www.tandfonline.com/loi/icnv20

Could Machine Learning Improve the Prediction of Pelvic Nodal Status of Prostate Cancer Patients? Preliminary Results of a Pilot Study

B. De Bari, M. Vallati, R. Gatta, C. Simeone, G. Girelli, U. Ricardi, I. Meattini, P. Gabriele, R. Bellavita, M. Krengli, I. Cafaro, E. Cagna, F. Bunkheila, S. Borghesi, M. Signor, A. Di Marco, F. Bertoni, M. Stefanacci, N. Pasinetti, M. Buglione & S. M. Magrini

Future Perspectives

In 2018 *Hung et al.* considered the utility of ML algorithms to evaluate surgical performance during whole procedure robot-assisted radical prostatectomy (RARP) and to predict patient outcomes.

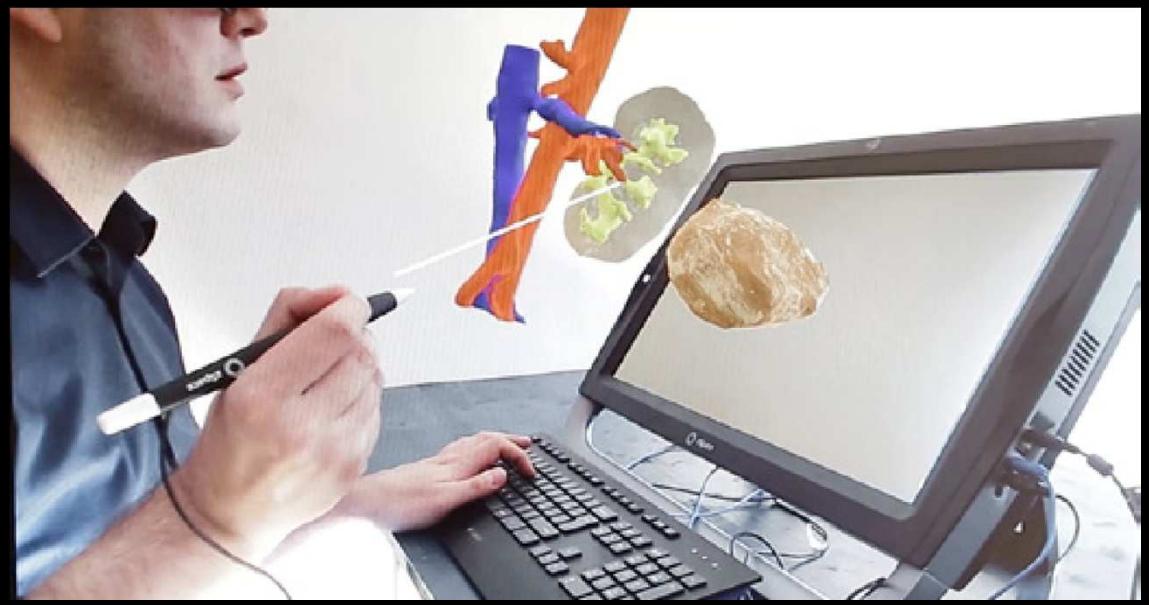
Deep learning on automated performance metrics and clinical features to predict urinary continence recovery after robot-assisted radical prostatectomy

Andrew J. Hung[1], Jian Chen[1], Saum Ghodoussipour[1], Paul J. Oh[1], Zequn Liu[2], Jessica Nguyen[1], Sanjay Purushotham[3], Inderbir S. Gill[1], Yan Liu[4]

They also evaluate the relative importance of individual automatic performance metrics (APM) in learning and predicting outcomes

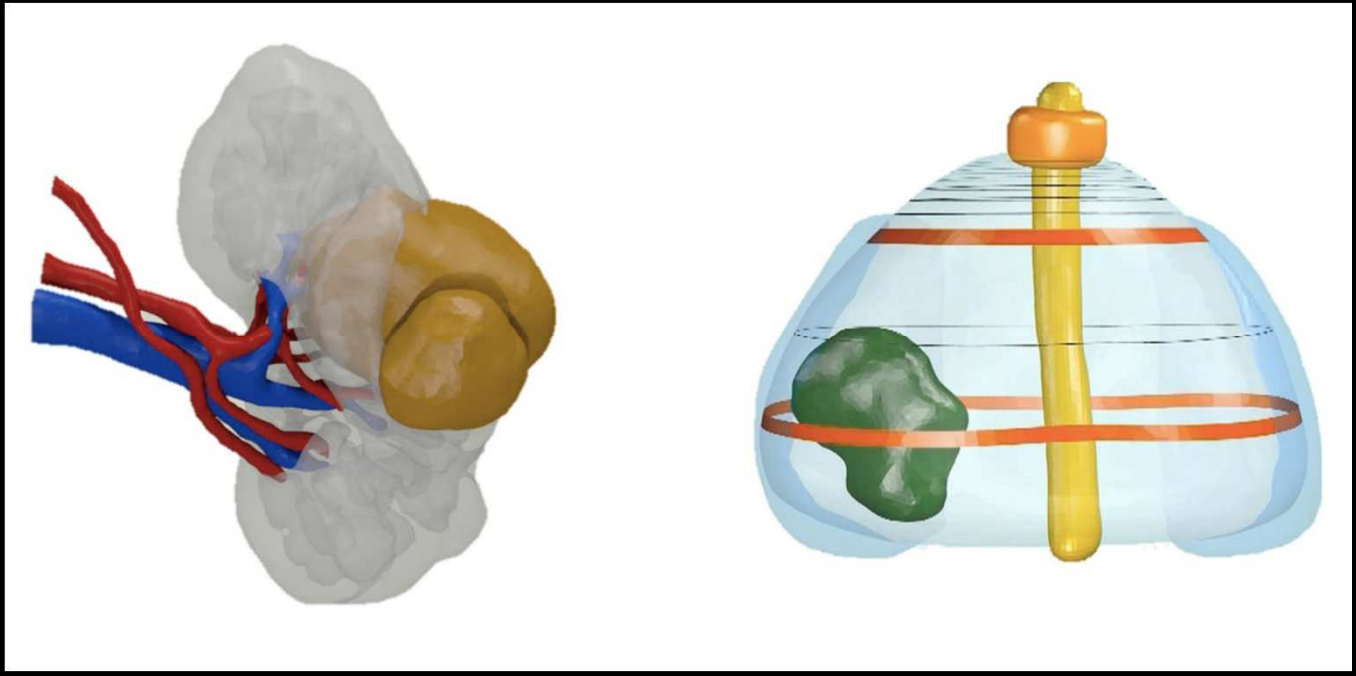
3D Imaging Applications for Robotic Surgery

3D reconstruction technology was first used in urology with the purpose of helping in surgical planning and intraoperative navigation, especially in the treatment of prostate and kidney cancer.

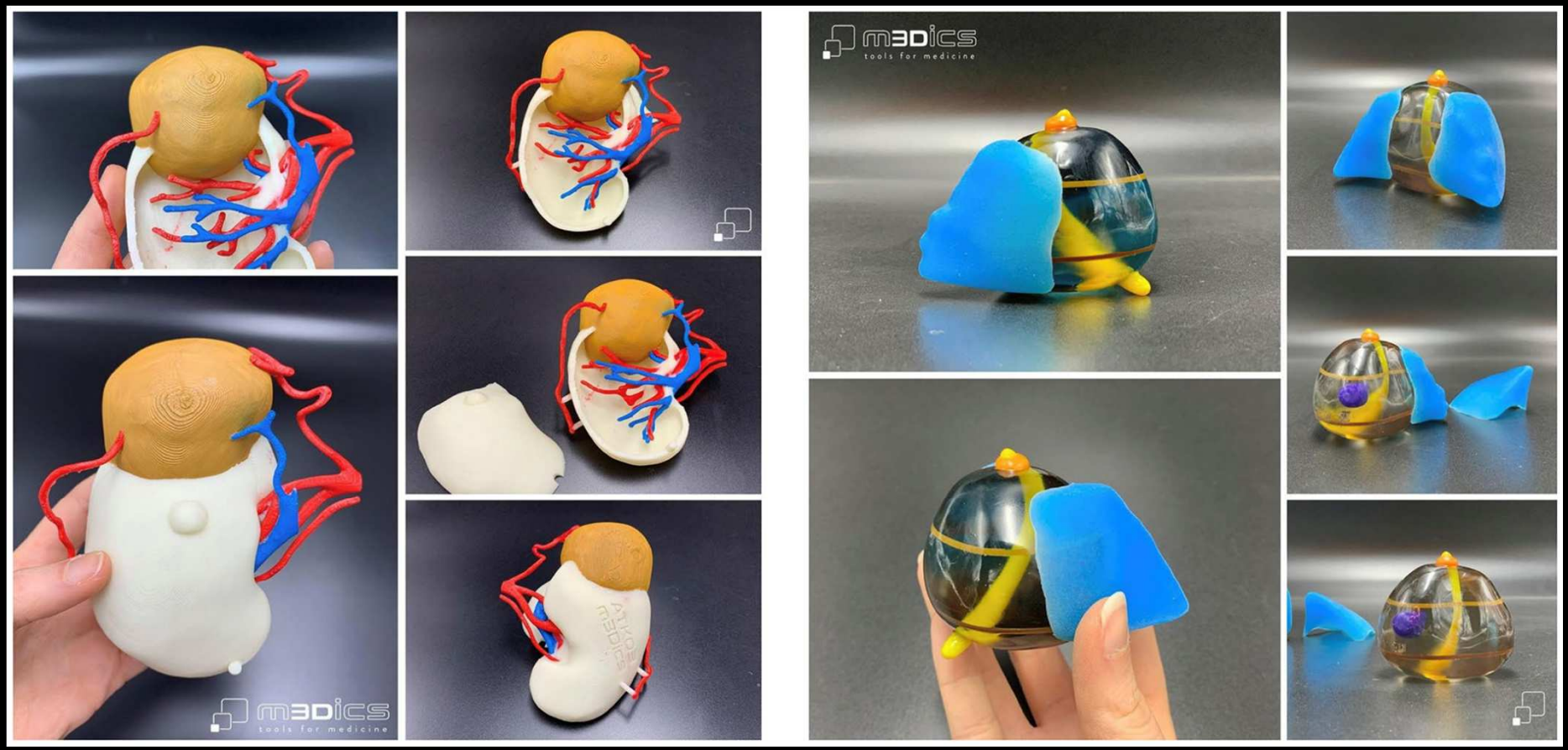


3D Virtual/Printed Cognitive Procedures

3D virtual models gave a better understanding of tumour location, endophytic rate, and relationship with vessels or nerves before surgery, leading to an increased indication for nerve-sparing or nephron-sparing surgery



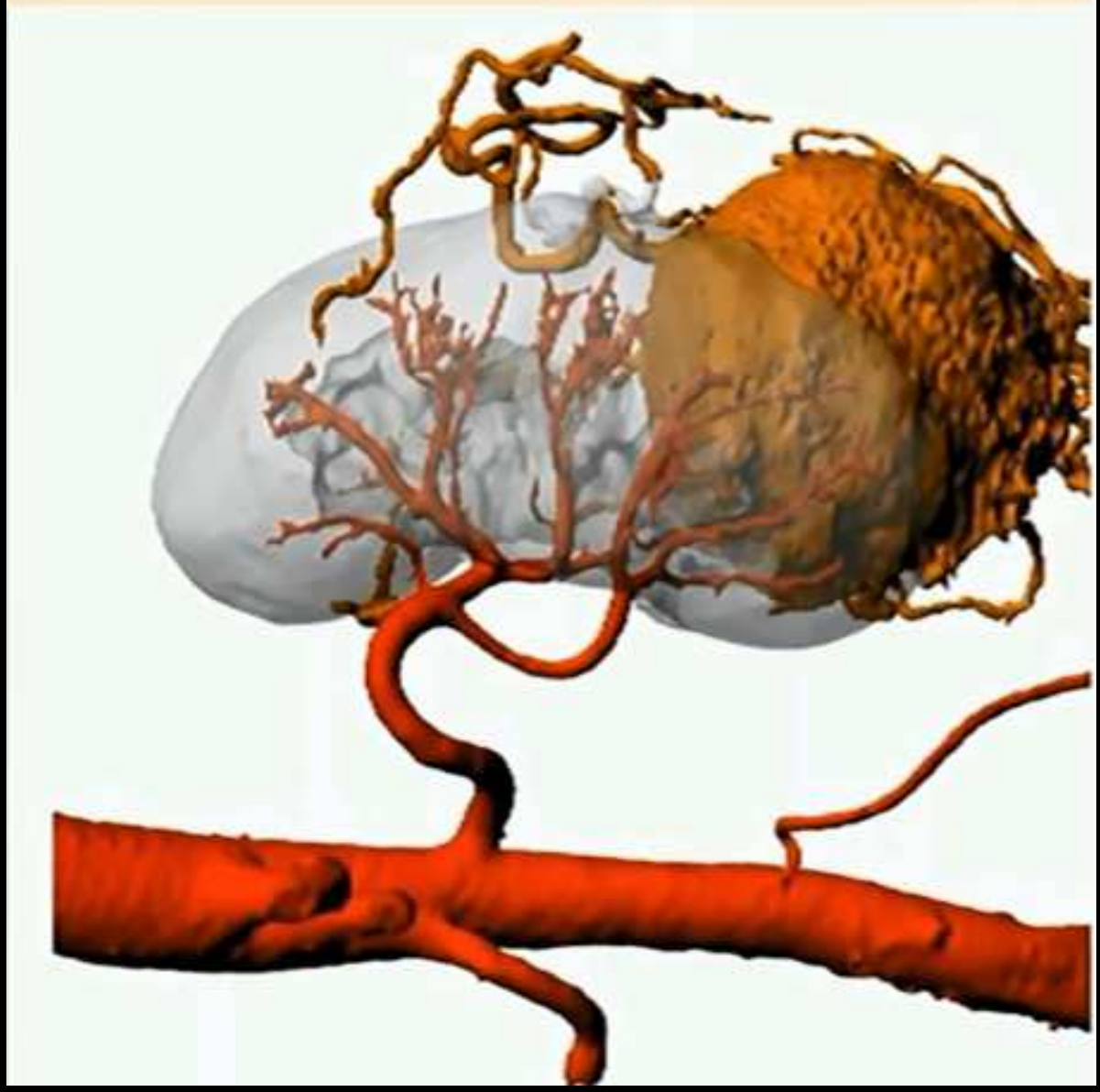
3D Virtual/Printed Cognitive Procedures



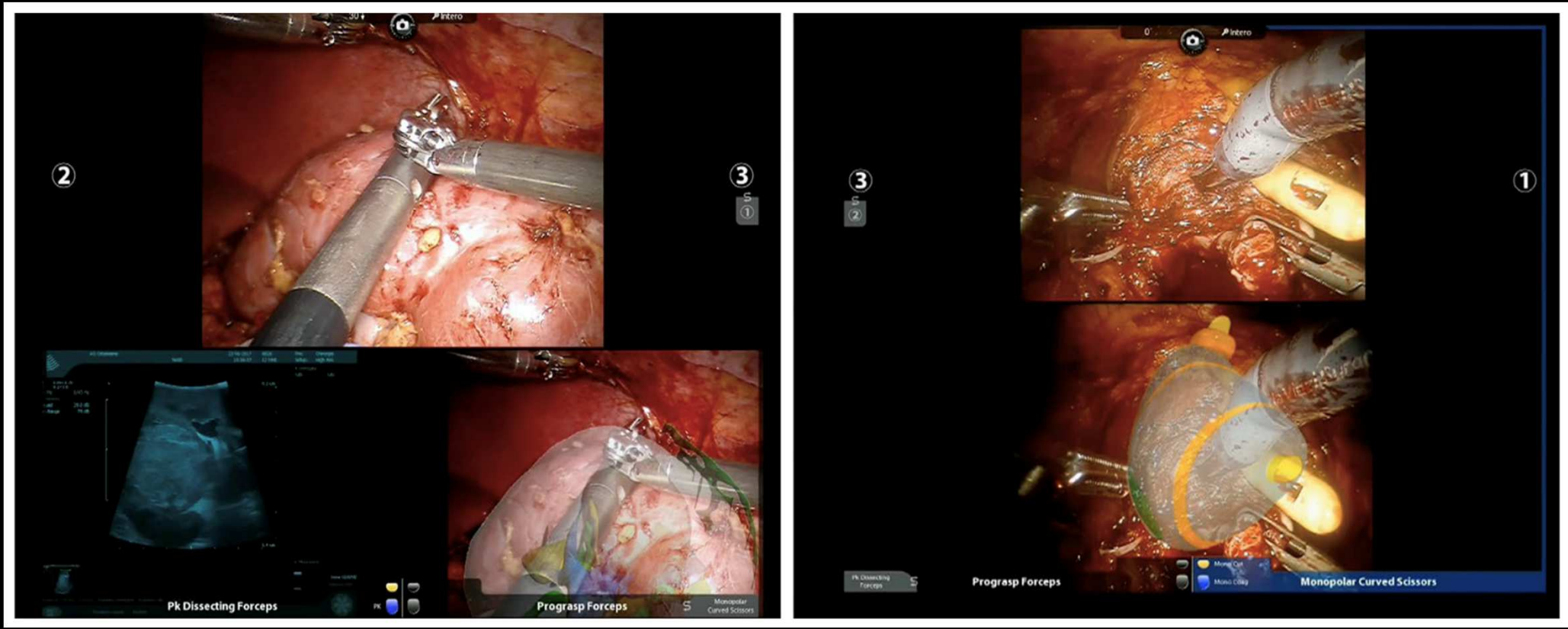
Holographic Reconstructions for Preoperative Planning before Partial Nephrectomy: A Head-to-Head Comparison with Standard CT Scan

Alessandro Antonelli[a] Alessandro Veccia[a] Carlotta Palumbo[a] Angelo Peroni[a] Giuseppe Mirabella[a] Alberto Cozzoli[a] Paolo Martucci[a] Filippo Ferrari[a] Claudio Simeone[a] Walter Artibani[b]

[a]Department of Urology, Spedali Civili Hospital, University of Brescia, Brescia, Italy; [b]Department of Urology, Azienda Ospedaliera Universitaria Integrata, University of Verona, Verona, Italy



3D Augmented Reality Procedures



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An Objective Assessment of Performance during Robotic Partial Nephrectomy: Validation and Correlation of Automated Performance Metrics with Intraoperative Outcomes

Saum Ghodoussipour, Sharath S. Reddy, Runzhuo Ma, Darryl Huang, Jessica Nguyen and Andrew J. Hung*

From the USC Institute of Urology, Los Angeles, California

Abbreviations and Acronyms

APM — automated performance

Purpose: Automated performance metrics provide a novel approach to the assessment of surgical performance. Herein, we present a construct validation of automated performance metrics during robotic assisted partial nephrectomy.

Automatic Performance Metrics

But if we used this progress in the form of new assistance tools that can enhance the abilities and performance of surgical teams?

The daVinci Logger

A “black box”-style recording device developed by robotic surgical platform industry leader Intuitive Surgical® may be able to objectively measure surgeon’s proficiency during robotically-assisted surgeries.

The dVLogger is designed to capture both anonymized video and movement data from the da Vinci robotic surgical platform after being attached to the system.

The box, and evaluation of the recordings it makes, could create a sustainable, objective method for analyzing surgeon proficiency and to standardize credentials to improve patient safety.

The daVinci Logger

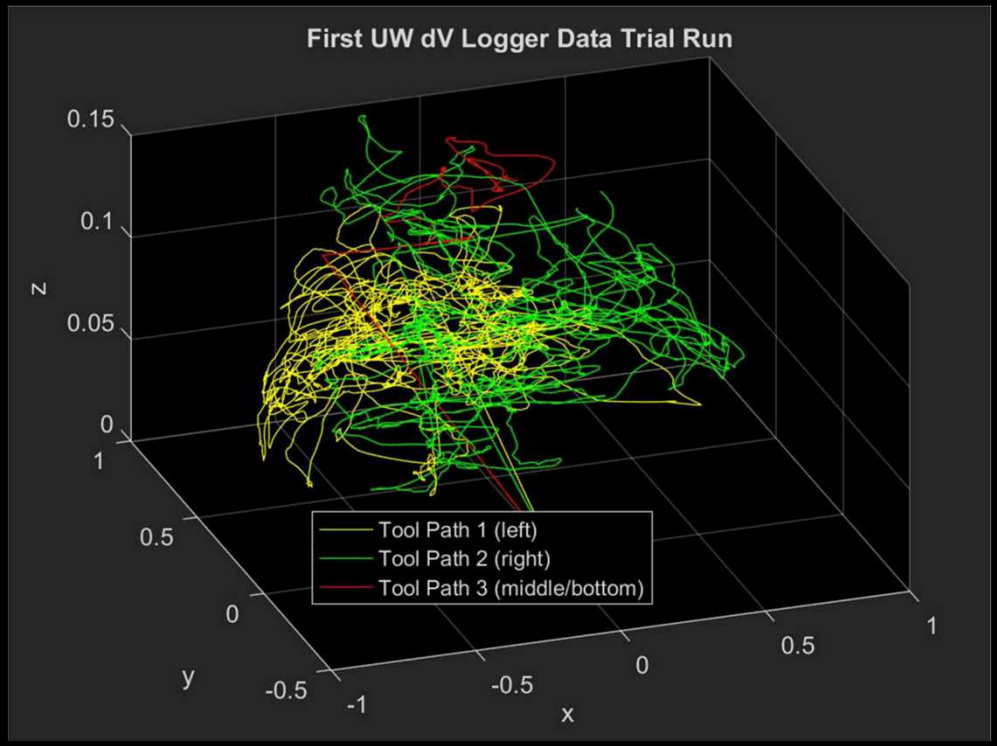
The dV Logger provides to surgeons training in robotic surgery simulation activities to meet proficiency.

This has been accomplished through peer and one-on-one training with an expert.

The Proficiency Training introduces novices and hones experienced clinicians in robotic object transfer, suturing, management of the third working arm, camera and instrument clutching skills.

The daVinci Logger

Data streams are available from dVLogger for extracting sample metrics like path length and working volume.



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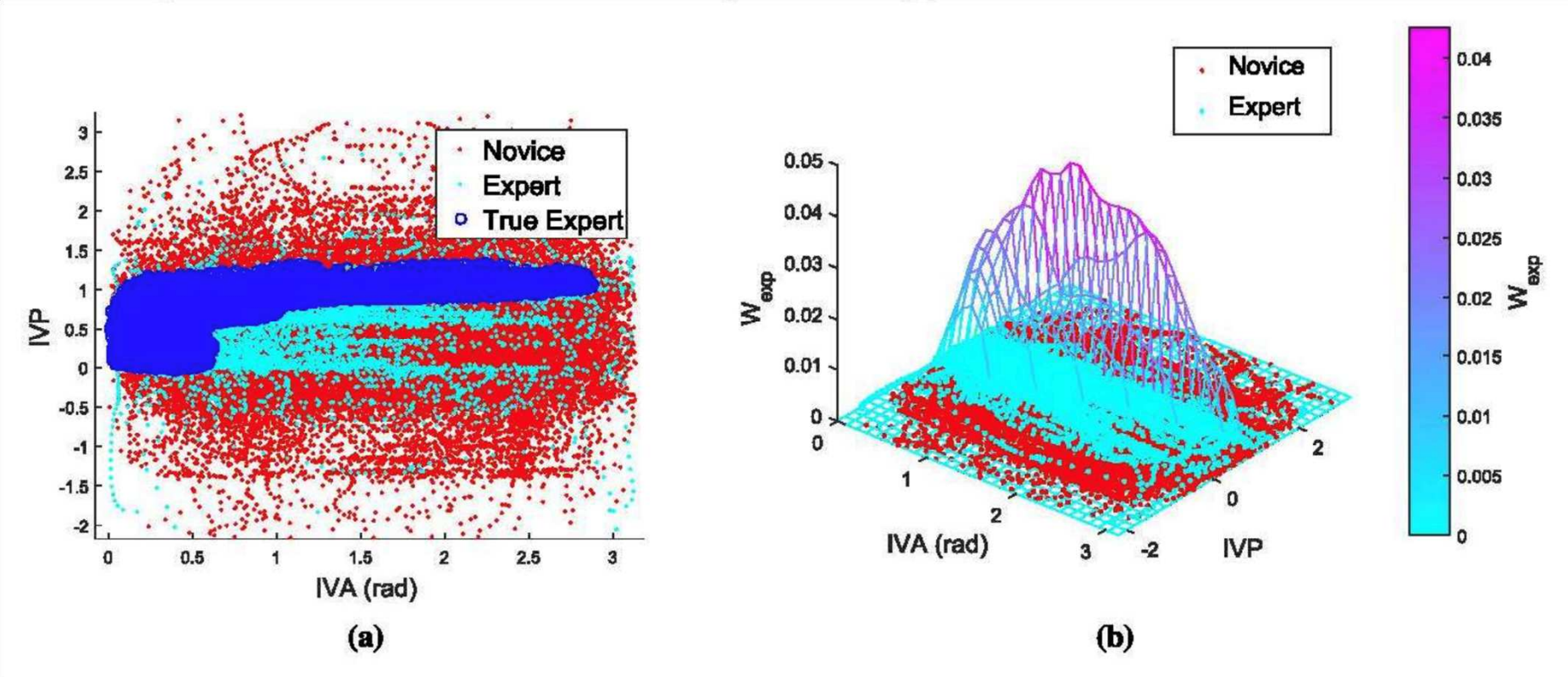
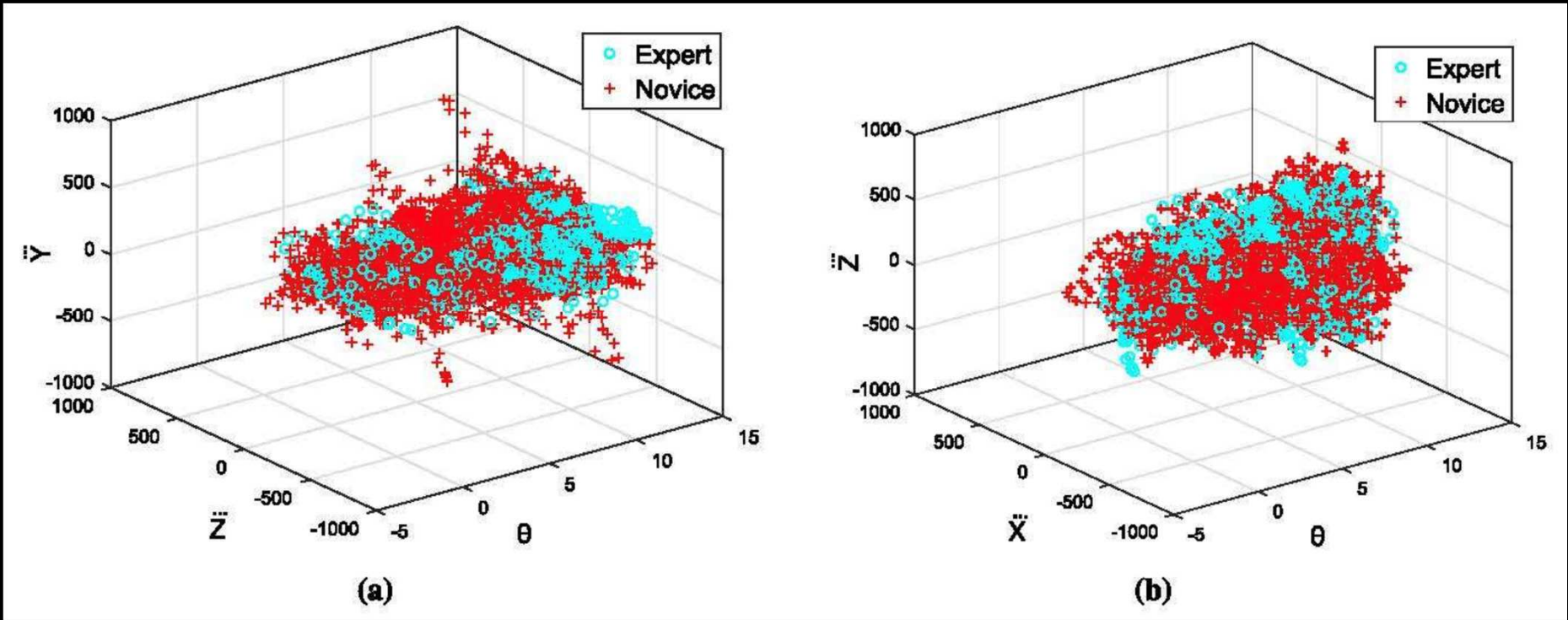


The daVinci Logger

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