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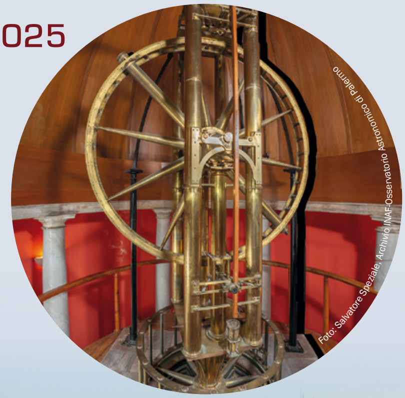


Università degli Studi di Palermo

INTERNATIONAL YEAR OF Quantum Science and Technology


Polo Didattico del Campus dell'Università di Palermo



**A cura di Barbara Alzani, Marco Bellacosa e Giovanna Bianchi Bazzi**
**Redazione dei testi a cura di Barbara Ancarani e Marco Bellacosa**
**Progetto grafico a cura di Simona Oleandri**

**Società Italiana di Fisica**

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### *In vivo* detection of dosimetric deviations in conventional radiotherapy using a deep learning framework.

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In the context of radiotherapy we developed a deep learning model to convert acquired EPID images into portal dose images, trained on a large dataset paired with Monaco TPS-calculated doses. This work assesses its applicability in an *in vivo* alert framework. We evaluate the model's sensitivity to controlled variations in Monitor Unit, patient positioning, and thickness. EPID images were acquired using anthropomorphic, modular heterogeneous phantoms, and solid water. A custom adipose-equivalent materials 3D-printed female torso phantom, with two interchangeable breast shapes, will be used for the final alert system evaluation. Dose difference, normalized dose difference, and gamma passing rate (GPR) were used as evaluation metrics. The system showed high sensitivity: for instance, for a $5 \times 5$ cm$^2$ field with the modular phantom, increasing the delivered MU from 100 to 104 led to a GPR drop from $(99.94 \pm 0.04)$% to $(75.95 \pm 0.61)$%; similarly, for a $2 \times 2$ cm$^2$ field, adding +2 cm of solid water caused the GPR to decrease from $(98.51 \pm 0.38)$% to $(77.28 \pm 1.32)$%. Results were compared using different DTA and DD criteria.

### Tackling the problem of diffusion in Fricke gels dosimeters through a physics-informed neural network algorithm.

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The use of radiation in medical applications demands accurate dose measurements, particularly with the advent of high-dose rates and mini-beam fields. In this context, Fricke gels (FGs) are gaining interest for their tissue-equivalent properties. FGs rely on $Fe^{2+}$ to $Fe^{3+}$ oxidation upon radiation exposure, that can be quantified by MRI or optical absorption (OA)

spectroscopy, enabling access to 3D dose distributions (DD). Ion diffusion brings to blurring effects in the recorded DD, limiting FG's clinical utility. The process is governed by the diffusion equation and reconstructing the backward time DD leads to a challenging inverse problem. A promising solution is given by the physics-informed neural networks (PINNs), which integrate physical laws with machine learning to solve partial differential equations. In this study, we trained PINNs to predict pre-diffusion DD in 1D, 2D, and 3D FG models, exploiting diffused data up to 100 hours post-irradiation. Predictions were compared with OA data from irradiated PVA-GTA gel and simulated data. Predictions MSE ($10^{-6}$–$10^{-4}$ OD2) and gamma analysis (90–100% passing rate at 3%/2 mm) indicate the PINNs potential in overcoming FG limitations.

**Classificazione automatica di organoidi intestinali tramite deep learning.**

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Gli organoidi epiteliali intestinali rappresentano un modello fondamentale per lo studio delle cellule staminali e del cancro colorettale, ma la loro classificazione manuale è lenta e soggettiva. In questo studio è stato sviluppato un modello di classificazione automatica basato sul deep learning, utilizzando YOLOv10m (You Only Look Once), una rete neurale convoluzionale per l'object detection in immagini. Il modello è stato addestrato su un dataset pubblico contenente 840 immagini di microscopia annotate (23066 oggetti), con l'obiettivo di identificare quattro categorie: cisti, organoidi precoci, organoidi tardivi e sferoidi. Il training, eseguito per 150 epoche, ha raggiunto le prestazioni ottimali all'epoca 80, con una mean Average Precision (mAP) pari a 0.85. Le migliori performance si sono osservate nella classificazione delle cisti (mAP 0.87). Il sistema misura anche le dimensioni degli organoidi con accuratezza comparabile a quella degli esperti, ma in modo molto più rapido. Questo approccio basato su deep learning apre la strada a un'analisi scalabile e ad alta efficienza nel campo della biologia degli organoidi. Lo studio rientra nel progetto PNRR PE00000019-HEAL ITALIA.

**Leveraging explainable deep learning for mammographic breast cancer diagnosis.**

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Breast cancer remains one of the leading causes of cancer-related mortality among women worldwide, and early, accurate diagnosis is key to improving patient outcomes. We explore the integration of deep learning with explainable AI (XAI) techniques for automated classification of mammographic lesions using the publicly available CBIS-DDSM dataset. Convolutional Neural Networks (CNNs) are trained to discriminate between malignant and benign findings, while Grad-CAM generates class-specific saliency maps highlighting regions most responsible for each prediction. This approach aims to enhance diagnostic accuracy and model transparency, offering visual explanations that support trust and clinical usability. We further investigate how lesion type and breast tissue density influence classification performance and interpretability of model outputs, suggesting pathways for individualized AI-based screening tools. This study is part of the EUCAIM project: Cancer Image Europe provides a secure platform for sharing annotated cancer images, enabling robust benchmarking of AI tools and fostering collaboration among researchers, clinicians, and innovators.