Black Paper: Deep Learning in Radiotherapy [DLinRT.eu] – Declaration of intent and preliminary roadmap

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This white paper presents an overview of the current landscape of deep learning applications in radiotherapy, as facilitated by the community-driven platform DLinRT.eu. It aims to address the challenges of fragmentation and inconsistency in terminology, while providing structured insights into technological maturity and clinical relevance. By outlining available technologies, defining tasks, and mapping solutions to Technology Readiness Levels (TRLs), this document serves as to define the intent underlying the DLinRT.eu platform aiming to become a key reference for stakeholders in the field.

1. Introduction

1.1 Motivation

The application of deep learning in radiotherapy is accelerating, leading to fragmentation, inconsistent terminology, and a lack of clear overviews on technological maturity. DLinRT.eu responds to this by offering structured insights for the community, by the community—free from commercial bias.

1.2 Goals

- Provide overviewable access to well-reviewed, structured information.
- Promote a unifying taxonomy to describe DL tasks in radiotherapy.
- Define clinically relevant tasks and match them with technological solutions.
- Quantify Technology Readiness Levels (TRLs) to support clinical translation.
- Ensure transparency and traceability in methodology, datasets, and results.
- Collect evidence supporting the clinical use of DL-based product and make it available to the community.

2. Community-Driven Framework

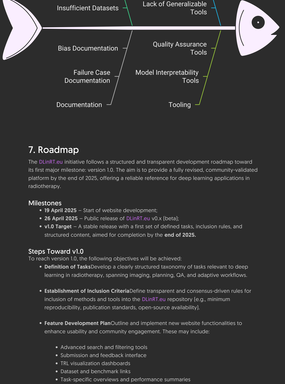
DLinRT.eu thrives on broad participation from academic, clinical, and industrial stakeholders. It is a living repository that evolves through contributions, consensus, and peer review. This white paper serves as a foundational reference capturing the field's current status and methodology.

3. Defining the Landscape

3.1 Taxonomy of Tasks

Tasks are grouped across the radiotherapy workflow, including:

- **Imaging**: Reconstruction, enhancement.
- **Segmentation**: Organs-at-risk (OARs), targets.
- **Registration**: Deformable, rigid.
- **Treatment Planning**: Dose prediction, optimization.
- **Quality Assurance (QA) and Verification**: Plan QA, patient-specific QA.
- **Performance monitor**: Non-AI software intended to evaluate the solution during commissioning and following the performance in time.



Each task is described with standardized metadata: clinical context, input/output type, required data quality, and potential performance metrics.

3.2 Modalities and Domains

Each solution is mapped by:

- **Imaging modality:** CT, MR, PET, CBCT, X-Ray.
- **Anatomy:** Abdomen, Body, Brain, Breast, Head & Neck, Pelvis, Prostate, Thorax, Whole body.
- **Open-source availability:** Data access, code reproducibility.

4. Technology Readiness Levels [TRLs]

A core feature of DLinRT.eu is assigning TRLs to each DL solution based on:

- Published validation.
- Generalizability across centers.
- Clinical deployment or trials.
- Certification (e.g., CE marking, FDA clearance).

This allows users to distinguish between experimental tools and those suitable for clinical integration.

5. Certification & Regulation

An overview of AI certification standards in radiotherapy is included, with references to:

- **Medical Device Regulation (MDR)** EU Medical Device Regulation.
- **FDA Software Guidelines:** U.S. Food and Drug Administration software guidelines.
- **ISO/IEC Standards:** Standards for software in medical devices.

Solutions in DLinRT.eu are flagged according to their certification status and intended use.

6. Challenges and Gaps

- Lack of standardized benchmarks and datasets.
- Insufficient documentation on failure cases and biases.
- Limited access to certified, generalizable DL tools.
- Lack of easily accessible evidence.
- Need for better tooling in model interpretability and QA.

DLinRT.eu highlights areas requiring further research and development to enable safe and robust clinical deployment.

7. Roadmap

The DLinRT.eu initiative follows a structured and transparent development roadmap toward its first major milestone: version 1.0. The aim is to provide a fully revised, community-validated platform by the end of 2025, offering a reliable reference for deep learning applications in radiotherapy.

Milestones

- **19 April 2025** – Start of website development.
- **26 April 2025** – Public release of DLinRT.eu v0.x (beta).
- **v1.0 Target** — A stable release with a first set of defined tasks, inclusion rules, and structured content, aimed for completion by the **end of 2025.**

Steps Toward v1.0

To reach version 1.0, the following objectives will be achieved:

- **Definition of Tasks**Develop a clearly structured taxonomy of tasks relevant to deep learning in radiotherapy, spanning imaging, planning, QA, and adaptive workflows.
- **Establishment of Inclusion Criteria**Define transparent and consensus-driven rules for inclusion of methods and tools into the DLinRT.eu repository (e.g., minimum reproducibility, publication standards, open-source availability).
- **Feature Development Plan**Outline and implement new website functionalities to enhance usability and community engagement. These may include:
  - Advanced search and filtering tools
  - Submission and feedback interface
  - TRL visualization dashboards
  - Dataset and benchmark links
  - Task-specific overviews and performance summaries

DLinRT.eu will continue to evolve through versioned releases, enabling a living overview of the field as it grows in scope, depth, and clinical relevance

8. Vision Forward

By unifying the field through transparent documentation, community consensus, and TRL-based evaluation, DLinRT.eu paves the way for responsible innovation and smoother translation of DL tools into clinical radiotherapy workflows.