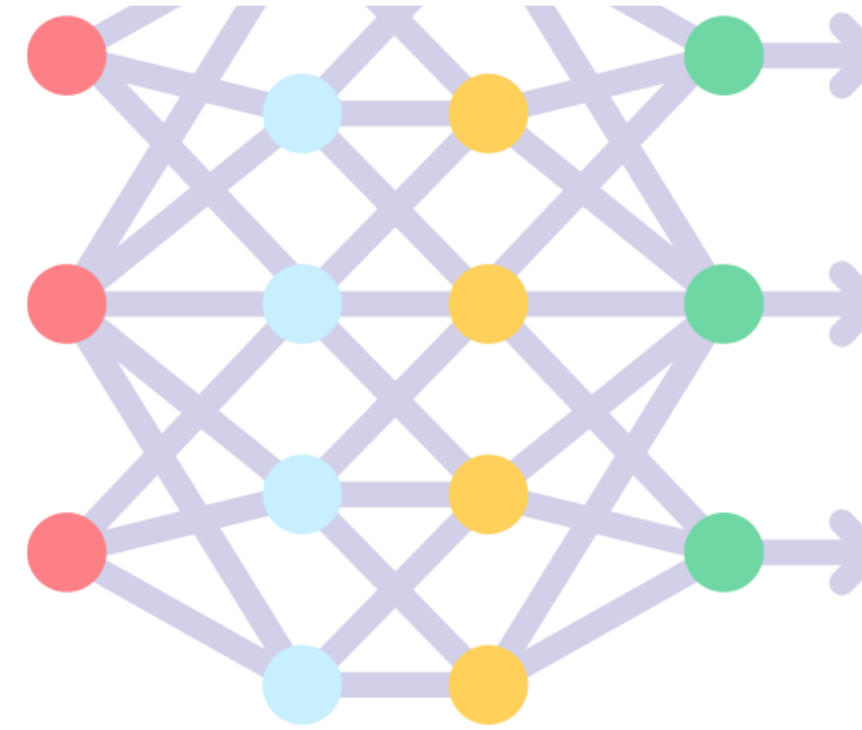


ADAPTIVE RESOLUTION SYSTEM FOR MEDICAL IMAGES - SRAIM



Modello DWTSRNet

Discrete Wavelet Transform Super Resolution Network for medical single image super-resolution



- Problem vs Solution
- SRAIM: Solution Description, Results, and Development Status
- Market Analysis
- Solution Completion Steps
- Investments and ROI

PROBLEM vs SOLUTION

Medical Hardware



High-resolution images
EXPENSIVE and ENERGY-INTENSIVE



Quality proportional to
RADIATION DOSE



Quality proportional to
ACQUISITION TIME

Super-Risoluzione



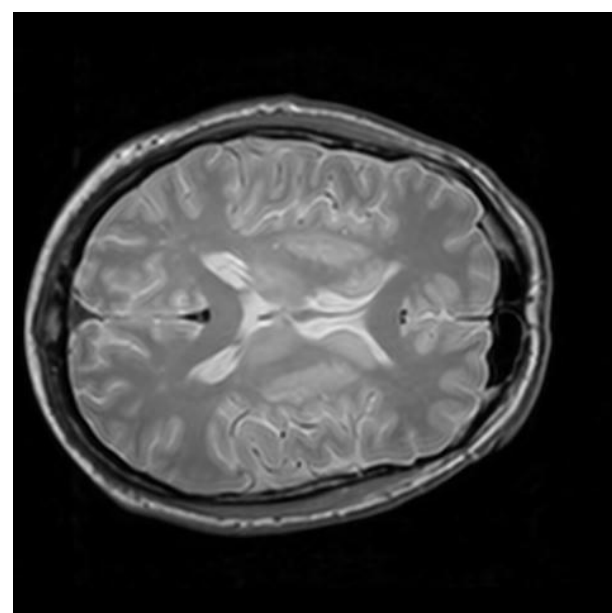
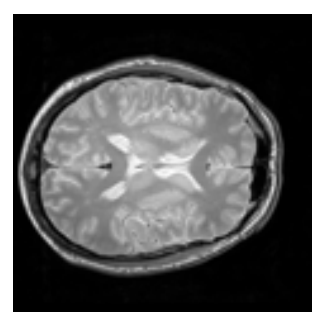
High resolution images at a
REDUCED COST



With the same quality
REDUCED RADIATION



With the same quality
TIME SAVINGS



Super-Resolution (SR) is an inference process that generates a high-resolution estimate of a low-resolution image.

In the **medical field**, this technology processes the raw data acquired during scans to generate additional coherent pixels, eliminating the need for a hardware upgrade..

SRAIM (DWTSRNet model)

WAVELET SPACE

- Exploit the SPARSITY of MRI images
- Separate STRUCTURE from DETAILS

DATA-DRIVEN CORRECTION

- It acts as a CORRECTION to a classic upscale.
- Data-driven contribution SEPARABLE from the output.



TRANSFORMER

- Utilize the EXPRESSIVENESS of transformers
- Limit COST using SWIN-TRANSFORMER

Dataset

Dataset	Tipologia	Quantità	Dimensioni HR	Utilizzo
DF2K	Generiche	50.000	256 × 256	Pre-Training
IXI	MRI Cervello	41.760	240 × 240	Training
OasisBrain1	MRI Cervello	12.480	256 × 256	Training
BrainTumorV2	MRI Cervello	8.822	256 × 256	Training

LR images are produced by
DOWNSAMPLING and NOISE

The model is trained on GENERAL and
MEDICAL datasets

Training

1 The first phase of training is a
GENERIC PRE-TRAINING

2 The second phase is a
MEDICAL TRAINING

Optimization: Adam algorithm and learning rate of 0.0002 with 4 refinement steps, one every 20k iterations, for stability and convergence.

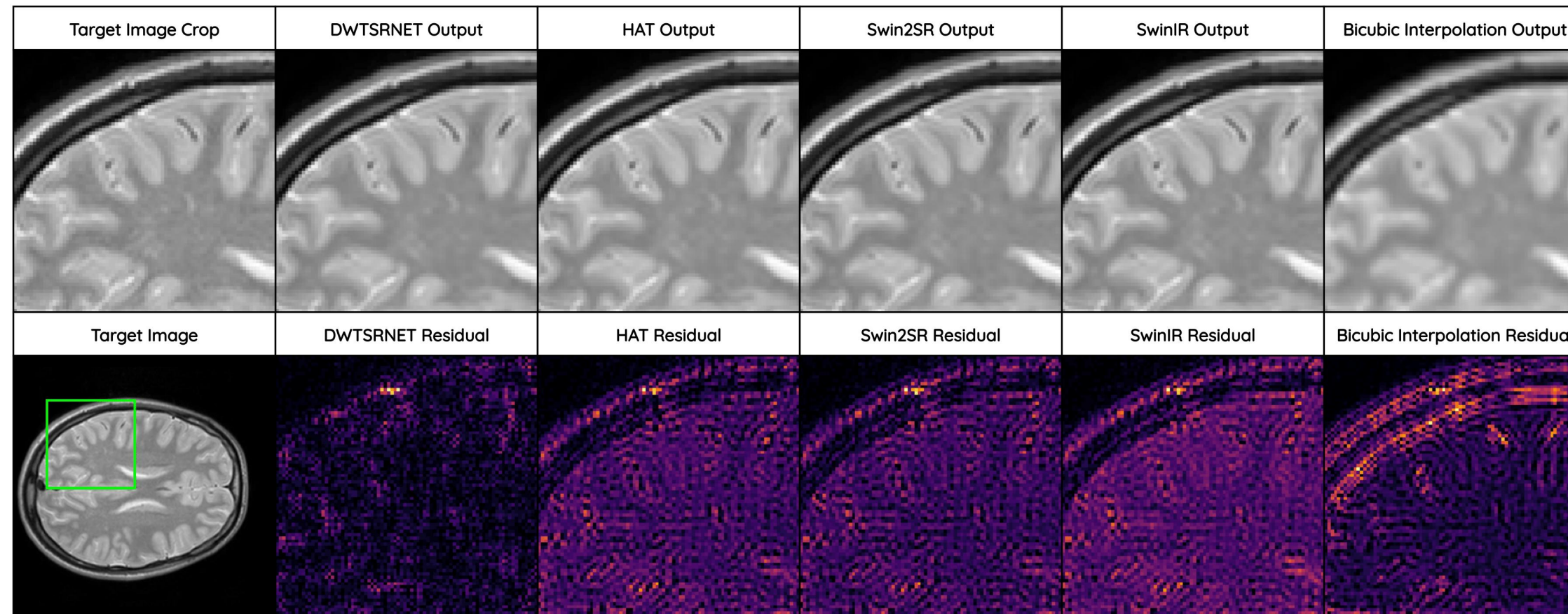
Data Management: Total of 100 pre-training epochs and 20 training epochs with random sampling (64x64 patch).

Model: Orthonormal Haar wavelet filters and 16x16 local windows for the swin-transformer.

DWTSRNet Results

Qualitative Results

comparison with other swin-based architectures



Compared to other swin-based models, DWTSRNet RECOVERS MORE DETAILS

Quantitative Results

comparison of different DWTSRNet configurations

The short version matches the 180 VERSION BY USING WAVELETS

Embedding	Params	FLOPs	Wavelet Weights	PSNR \uparrow	SSIM \uparrow	LPIPS \downarrow
180 channels	11.87 M	61.67 G	uniform	37.62	.9802	.0681
96 channels	3.52 M	21.13 G	uniform	37.35	.9796	.0740
96 channels	3.52 M	21.13 G	data-driven	37.65	.9810	.0703

The **DWTSRNet** model was trained on open-source public Datasets and validated on image samples.

The validation phases, performed by image **DOWNSAMPLING** and **NOISE** introduction, demonstrated:

- Very high model reliability;
- Reduced computational resource requirements;
- High image quality, comparable to that produced by high-resolution machines.

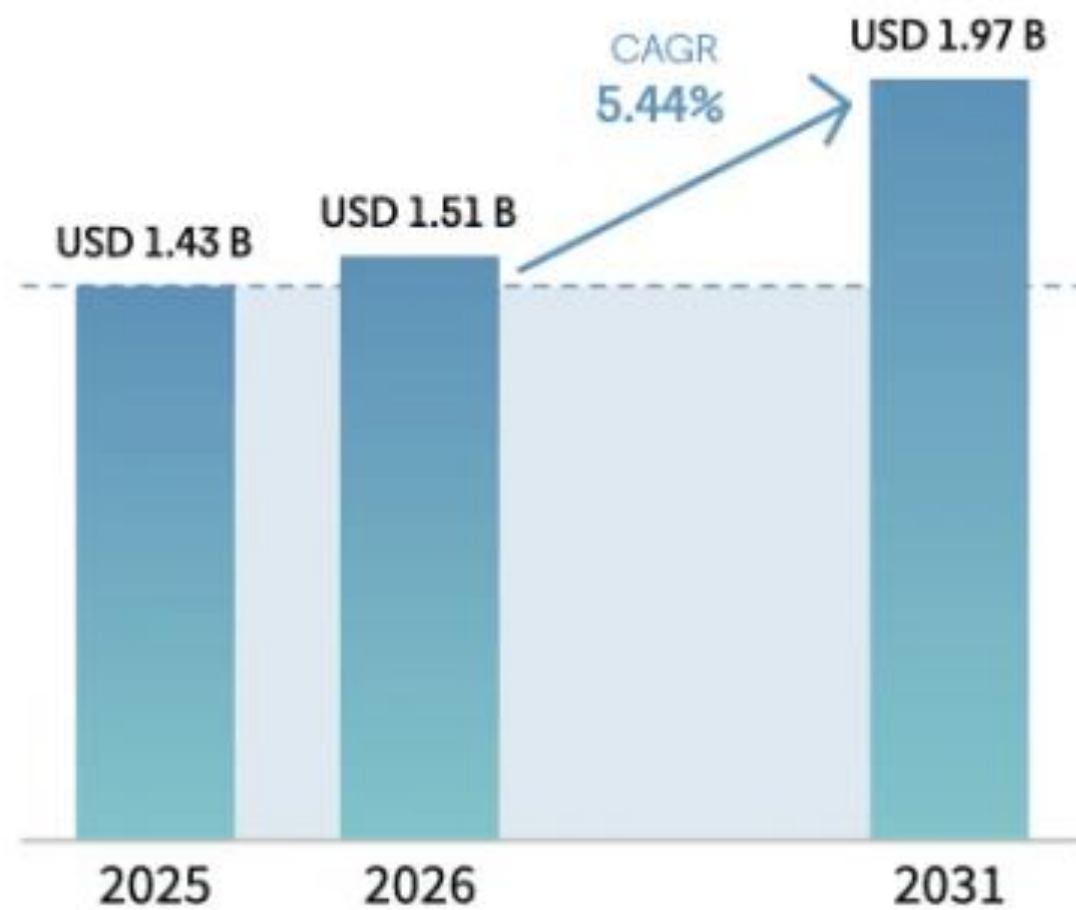
Industrial Patent Application No. 102025000033919 was filed on December 17, 2025.



Market Analysis 1/3

Italy Diagnostic Imaging Equipment Market

Market Size in USD Billion



Source: Mordor Intelligence



Panoramica di mercato

Periodo di studio	2020 - 2031
Anno base per la stima	2025
Periodo dei dati di previsione	2026 - 2031
Dimensione del mercato (2026)	1.51 miliardo di dollari
Dimensione del mercato (2031)	1.97 miliardo di dollari
Tasso di crescita (2026 - 2031)	5.44% CAGR
Concentrazione del mercato	Alta

Principali giocatori



Capacity upgrades funded by the National Recovery and Resilience Plan (NRRP) and private sector investments are accelerating equipment replacement cycles and digital connectivity. Demand is being driven by an aging population and the high burden of oncology and cardiovascular diseases.

Source: <https://www.mordorintelligence.it/industry-reports/italy-diagnostic-imaging-equipment-market-industry>

Aging Population and Rising Incidence of Chronic Diseases

In Italy, aging is driving a dramatic increase in chronic diseases, with 57% of people over 65 suffering from at least one chronic condition and a quarter having more than two. The share of people over 65 is expected to increase significantly by 2065, exceeding **32-33%** of the total.

Workflow automation and patient comfort features are becoming a priority, as frail patients require longer positioning times.

In Italy, there are nearly 37,000 diagnostic imaging devices, with:

- approximately **18,000 machines** (CT, MRI, and mammography) **obsolete or outdated**, often over 10 years old.
- By 2026, the National Health System is expected to upgrade with over **3,000 new machines**.

High cost of imaging equipment and procedures

Direct healthcare spending has increased, and investment budgets at smaller hospitals are lagging behind the recommended five- to seven-year replacement cycles, reducing demand for hybrid scanners and high-end MRIs.

Vendors that combine **low-dose protocols with rapid image reconstruction are gaining a competitive advantage in the Italian diagnostic imaging equipment market**.

Key details on the Italian technology park:

Obsolescence: According to Confindustria Medical Devices and industry reports:

- **92% of mammograms;**
- **96% of CT scans (with fewer than 16 slices) are more than 10 years old;**
- **Over 50% of medium-intensity MRIs (1.5 Tesla) are considered obsolete.**

Impact:

- Over **130 million diagnostic imaging exams are performed annually in Italy**, a significant increase compared to the past.
- MRI is expected to grow at a **CAGR of 7.17%**, as open-bore systems reduce claustrophobia.
- Neuro-oncology, musculoskeletal sports injuries, and cardiac viability studies are expanding their clinical indications, increasing MRI's share of the Italian diagnostic imaging equipment market, both for hospitals and private facilities.

Investments:

- **The PNRR (National Recovery and Resilience Plan) funds the replacement of older machines to improve the quality of services. (Source: Quotidiano Sanità)**
- The context highlights a strong need for modernization, particularly in cutting-edge technologies, to improve diagnostic accuracy.

TO-DO

To launch the SRAIM solution on the market, the steps to be taken, in collaboration with a neuro-oncology facility, are:

1. **Medical-scientific certification of DWTSRNet results**, through :

- a. "Free diagnostic analysis" campaign with double LR-HR scan (so that each LR image has a corresponding HR comparison)
- b. Model fine-tuning on a subset of the diagnostic images acquired in step a.
- c. Model testing and validation on the remaining dataset acquired in step a.
- d. Final analysis and validation performed by a medical committee of the HR images produced by SRAIM

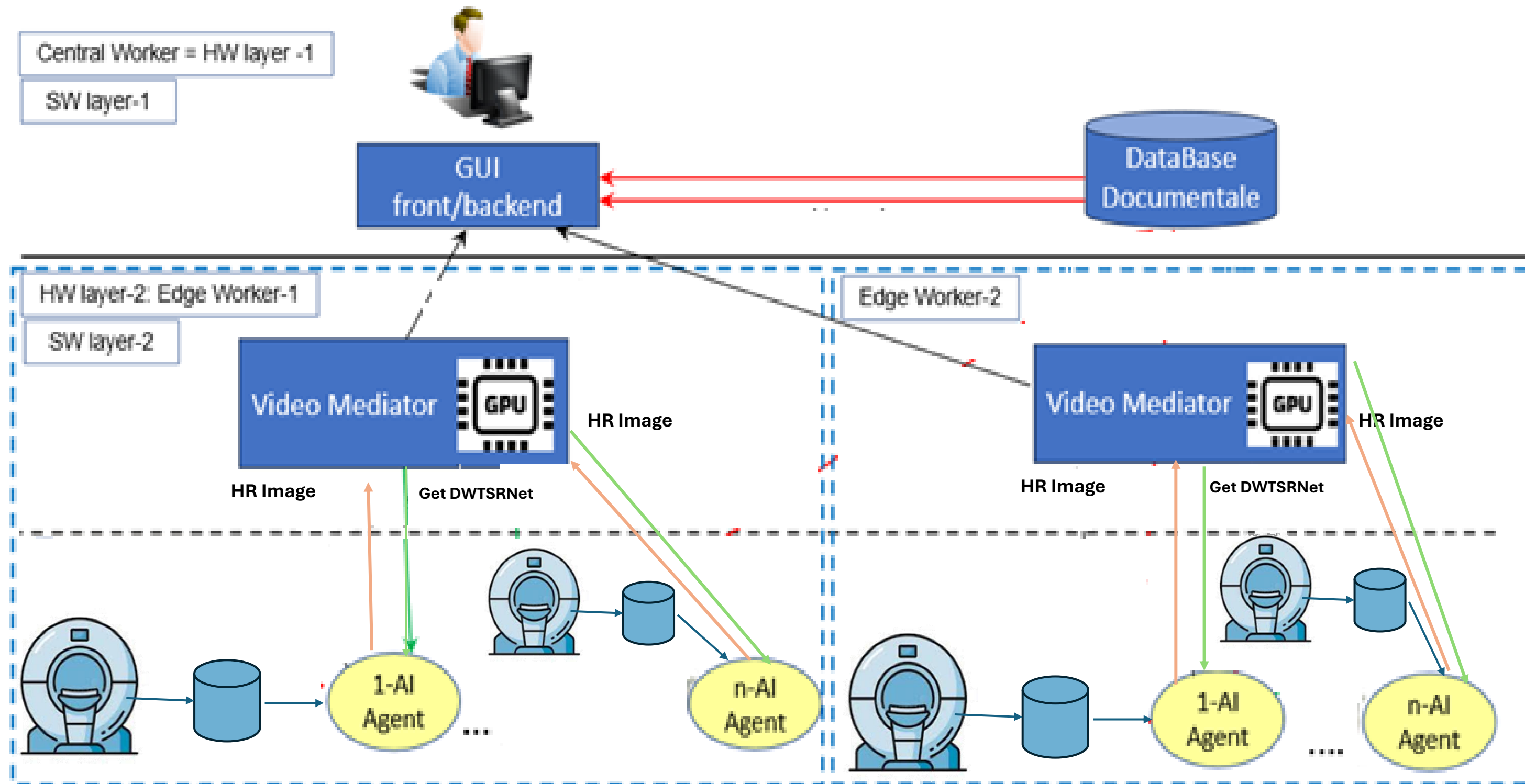
2. **Analysis and definition of functional requirements for the SRAIM user interface**

3. **Fine-tuning of SRAIM's architectural and software components:**

- a. Front-end (with a related "User Management" component for secure access management);
- b. Back-end (Dockerized architecture based on K8s and NoSQL database);
- c. Security management, in compliance with cybersecurity regulations and best practices

SRAIM Architecture

Architettura: Hardware e Software





RIPROGRAMMAZIONE
REACT EU



MISSIONE 4
ISTRUZIONE
RICERCA



Finanziato
dall'Unione europea
NextGenerationEU

Ministero dell'Università e della Ricerca

- **Third-party agreement with the Department of Experimental Medicine of the University of Campania L. Vanvitelli**
- **Framework Agreement between Roma Tre University and Project Consulting**
- **Doctoral scholarship from the Ministerial Decree 118 Program – Digital and Environmental Transformation (funded by the Lazio Region) University-Company – Scholarship topic:**

Machine Learning e 3D Computer Vision

PhD in Mathematics starting January 1, 2024 - 3rd year

1st Year: 4 months of research at UPEC (University of Paris Est-Creteil) on Computer Vision - Start of SuperResolution research

2nd Year: Computer Vision in industrial settings (fall down, plate recognition, fighting)

3rd Year: 3 months of research at the Cambridge Image Analysis Group

Project Team



MORENA LA MONACA



MASSIMO FUCCI



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STEFANO CATANIA



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PIETRO CESTOLA



INDUSTRIAL RESEARCHERS



BIOMEDICAL RESEARCHERS



MATHEMATICAL RESEARCHERS