Newsletter #7

iToBoS

Intelligent Total Body Scanner for Early Detection of Melanoma

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 965221.

2024

Content

Submission and approval of the second Periodic Reporting

The second Periodic Reporting corresponding to the period M19-M36 was submitted to the EC on May 28th, 2024 (M38) and it was officially approved on August 20th, 2024.

Along this reporting period, 23 deliverables were submitted and two milestones have been achieved.

In total, six project meetings have been organized: three General Assembly meetings and three Project Management Board meetings. Additionally, several WP meetings and other project meetings have been organized by the Project Coordinator.

The bi-annual technical and financial reports of the consortium (M19-M24, M25-M30 and M31-M36) have been coordinated, monitored and reviewed by the Project Coordinator.

During the first 36 months, the project has made substantial progress in creating advanced tools for a comprehensive skin examination system. Initially, the overall architecture of the iToBoS system was defined, specifying system requirements and ensuring interoperability among the key modules. Then, the Data Management Plan (DMP) was established and the iToBoS cloud platform was completed, implementing the cloud infrastructure in accordance with the DMP.

A major advancement during the early months was the definition and validation of the high-resolution imaging module (HRIM), including the design of liquid lenses for image acquisition. Progress continued with the integration of this HRIM into a first prototype of the total body scanner. The development of this prototype was based on an arch concept carrying the HRIMs.

Due to component shortages causing delays in the construction of the total body scanner, a contingency plan was implemented, which included using the Vectra 360 scanner for initial image acquisition. Following this strategy, tools for image ingestion, anonymization, and masking of both images and patient data were adapted for use with the data acquired by the Vectra scanner.

As the project advanced, algorithms were developed for image processing, 3D reconstruction, lesion detection and classification, and data integration, as well as tools for applying machine learning to the data gathered using the Vectra.

A diverse dataset with various types of lesions from 496 patients of different skin types and UV damage has been collected during the reported period, corresponding to the clinical data acquisition trial, providing a resolution 60-80 microns per pixel. Manual annotation processes have been implemented to feed the AI algorithms with the data coming from the clinical data acquisition trial.

As new datasets became available, the development of a mole change detector made significant progress, leveraging machine learning frameworks for multi-temporal analysis to identify changes in lesions over time. This system produces a change detection score that aids in assessing disease progression. An explanation module describing and visualizing the AI system's reasoning during diagnosis has also been developed, enhancing the transparency and interpretability of AI-driven decisions.

Concurrently, the prototype of the Bosch Total Body Scanner was developed, capable of scanning a patient with a resolution of 20 microns per pixel.

During the second reporting period, we transitioned from the arch concept to a flexible design using collaborative robots that allowed for dynamic adjustment of camera positions, accommodating a wide array of patient profiles.

This second approach also addressed component scarcity in the market while ensuring comprehensive and precise imaging of the pigmented skin lesions.

Figure 1. Submission and approval of the second Periodic Reporting.

3D Reconstruction capabilities of the iToBoS Total Body Scanner

The total body scanner developed in the iToBoS project mounts four collaborative robots (cobots) that move independently in order to gather the skin lesions on a patient's body. In order to fulfil this goal, the scanner must first construct a 3D map of the patient's skin surface, in order to properly plan the positions of the moles to inspect. In this article, we will give a glimpse of the methodology followed to obtain such 3D map.

The imaging payload mounted at the end-effector of each cobot in the scanner comprises a triplet of cameras:

- A high-resolution RGB Lucid Triton camera, collecting images of the skin at naked-eye resolution.
- A 3D Lucid Helios2 camera, collecting depth readings and, consequently, 3D points clouds that reveal the 3D shape of the body of the patient.
- An Flir Oryx camera coupled with a liquid lens from Optotune, able to collect a stack of images at different focus distances that, when combined, render an image of a quality that resembles that of standard dermoscopy.

Mainly the Triton and Helios2 cameras are used when creating the 3D map of the patient, while the Oryx camera is only used in the final mole inspection process.

Via a complex calibration procedure, we are aware of all the rigid transformations between the different camera frames and each robot's end-effector. This effectively allows us to translate the 3D measurements captured by the Helios2 camera to a common reference frame. Therefore, in a first step, the robots move to pre-defined positions and take measurements from both the Triton and Helios2 cameras. The 3D measurements of each camera are then transformed to the common reference frame, such that the local 3D views are gathered together in a single 3D point cloud map (see Figure 2 (a/b)). Moreover, since the Triton and Helios2 cameras are mounted in a rigid configuration within the end-effector, they form a stereo pair. Thus, the know transformation between both camera frames, coupled with the known intrinsic parameters of each camera, allows us to colorize the 3D point set from the Helios2 camera by projecting it into the Triton image plane and taking the colour of the pixel where each 3D point projects to. All the processes above involve a low computational effort, and can therefore be executed in real time, while the patient is being scanned.

However, this 3D point cloud does not represent the surface of the skin of the patient. Actually, these points are just *measurements* taken from such surface. This means that in case we want to take new measurements on this surface (such as locating the moles on the patient's body) we must recover the underlying surface that these points represent.

Therefore, we need to convert this discrete point set into a more convenient continuous surface, and the most commonly used representation for a surface in computer science is a triangle mesh. In order to retrieve a surface triangle mesh from the point cloud map we apply the Screened Poisson surface reconstruction method [1] (see Figure 2 (c)). It is worth noting that, while not required in this project, the colour on the Triton image could also be used to provide a texture mapping to the reconstructed surface [2].

As previously mentioned, having the patient's skin in this surface form allows us to take measurements on it, and this is important for the next step of the scanning process, where we want to retrieve the precise 3D location of the skin lesions.

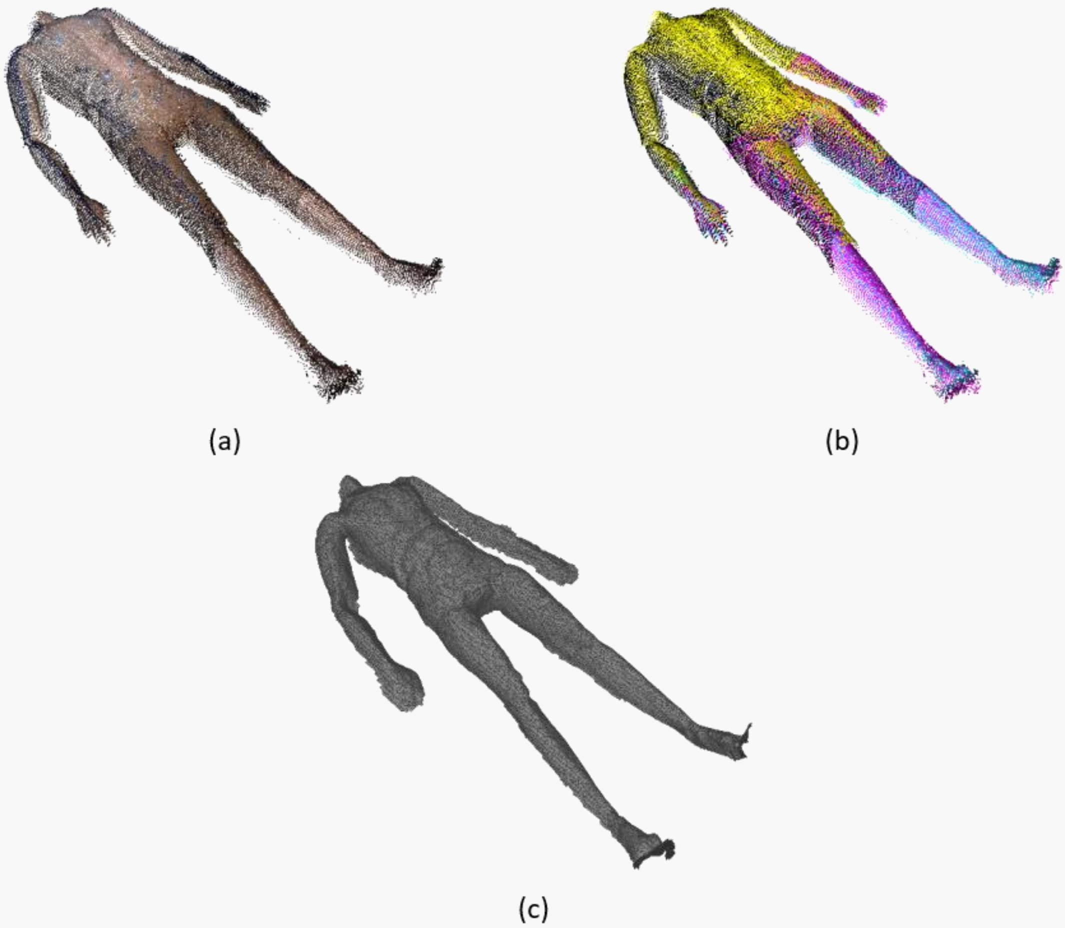


Figure 2. Sample 3D reconstruction of a manikin obtained from single shots taken from each of the four robots in the iToBoS scanner. You can see in (a) the global map joining all the point sets, in (b) the same map but colouring each point according to the robot it comes from, and finally in (c) the reconstructed surface triangle mesh.

[1] Michael Kazhdan and Hugues Hoppe. 2013. Screened Poisson Surface Reconstruction. ACM Trans. Graph. 32, 3, Article 29 (June 2013), 13 pages. https://doi.org/10.1145/2487228.2487237.

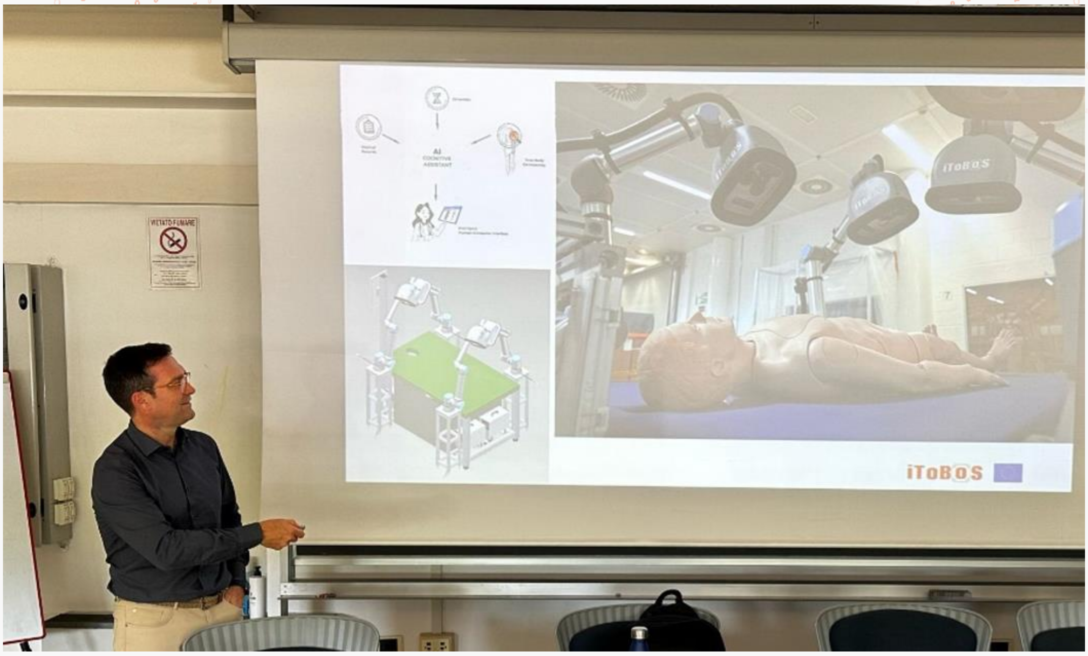
[2] Waechter, M., Moehrle, N., Goesele, M. (2014). Let There Be Color! Large-Scale Texturing of 3D Reconstructions. In: Fleet, D., Pajdla, T., Schiele, B., Tuytelaars, T. (eds) Computer Vision – ECCV 2014. ECCV 2014. Lecture Notes in Computer Science, vol 8693. Springer, Cham. https://doi.org/10.1007/978-3-319-10602-1_54.

Some project events and activities

In the seventh semester of the project, which covers from April 2024 to September 2024, iToBoS organized and participated in different events for communication, dissemination and outreach purposes.

iToBoS project representatives presented the project and shared experiences with a wide range of stakeholders, including relevant players from the fields of ICT, innovation, research, opto-electronics, healthcare, and business, highlighting the following events and activities:

- Athens, 12-14/04/2024, Automation & Robotics Expo 2024.
- Guadeloupe, 14-20/04/2024, Nano in Bio 2024 International Conference.
- Pisa, 27-31/05/2024, Course *Mastering Machine Learning Techniques: Application to Melanoma Detection*.
- Online, 31/05/2024, Meet iToBoS Series: *Ethical AI in iToBoS*.
- Trieste, 14-15/06/2024, Associazione Italiana di Diagnostica Non Invasiva in Dermatologia (AIDNID) annual congress.
- Online, 8/07/2024, Stakeholder workshop on the social and ethical impacts of XAI in healthcare.
- Budapest, 24/09/2024, iToBoS 8th GA and 7th PMB meetings.



Work presented

During the seventh semester of the project the following deliverables have been produced and submitted:

Deliverable submitted	Month	Leader	Diss. level
D10.2 Study subject approval package for the clinical feasibility study.	38	UQ	CO
D11.5 Third dedicated training module for Melanoma Patient Advocates.	38	MPNEsupport	PU
D9.1 Intelligent Human-Computer Interface (prototype).	39	CAN	CO
D10.7 A report evaluating the holistic risk model performance.	39	UQ	CO
D4.3 AI anonymisation and data minimisation tools.	40	IBM ISRAEL	CO
D7.7 Software and methods implementing XAI solutions for integration into cognitive assistance frameworks.	40	Fraunhofer	CO
D8.2 Methods for clinical and imaging AI-based quantitative risk assessment.	40	NTUA	CO
D8.4 Methods for change detection between lesions.	40	CORONIS	CO
D8.5 Tools for Image-based multi-class classification of lesions.	40	Torus	CO
D9.2 Test report on the integration and validation of the iToBoS system.	40	CAN	CO
D10.4 A collection of 500 Vectra 3D wholebody images annotated with clinical, imaging phenotypic and genetic data.	40	UQ	CO
D10.5 Report on status of posting results for the Vectra clinical study.	40	UQ	CO
D2.2 Privacy, data protection, social and ethical impact assessment final report for iToBoS.	42	TRI IE	PU

D2.3 Social and Ethical Issues for AI in the medical context Briefing Paper.	42	TRI IE	PU
D5.7 Scanner, testing protocols and hardware validation.	42	BOSCH	CO
D10.8 Midterm recruitment report for the feasibility study.	42	UQ	CO

Publications

During this seventh semester of the project the following scientific works have been published in the iToBoS context.

- *"Explainable AI for Time Series via Virtual Inspection Layers"*. 2024. Johanna Vielhaben, Sebastian Lapuschkin, Grégoire Montavon, Wojciech Samek.
- *"From Hope to Safety: Unlearning Biases of Deep Models by Enforcing the Right Reasons in Latent Space"*. 2024. Maximilian Dreyer, Frederik Pahde, Christopher J. Anders, Wojciech Samek, Sebastian Lapuschkin.
- *"Addressing the generalization of 3D registration methods with a featureless baseline and an unbiased benchmark"*. 2024. David Bojanić, Tomislav Petković, Tomislav Pribanić, Kristijan Bartol, Josep Forest.
- *"Perspectives for Generative AI-assisted Art Therapy: Bridging Creativity and Technology: Innovating Art Therapy with Generative AI"*. 2024. Lennart Jütte, Ning Wang, Martin Steven, Bernhard Roth.

In addition, different articles aimed at broader audiences have been developed and published on the project website, presenting the project from different perspectives, considering the different profiles of all the project partners.

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iToBoS team

The consortium with 20 partner organizations is led by the University of Girona (Spain). This international consortium brings together **leading research / academic institutions** (5 **research centres**), **industries** (4 large companies and 7 SMEs) and **end-user entities** (3 hospitals and 1 patients' NPO).

The University of Queensland has received funding from the Australia's NHMRC under grant number APP2007014.

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Let's stay in contact!

iToBoS has deployed some **digital channels to keep in touch with you and bring you the latest news** about the project. They are also a way to receive your ideas and comments as well as learn more about your needs.

iToBoS
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