Qumphy

Newsletter

May 26, 2025

What is QUMPHY About?

Need Photoplethysmography (PPG) signals are rich in information and easy to measure passively without any physical or mental limitations of the subject. As it is impossible for physicians to infer physiological parameters from the PPG signal by themselves, they need to rely on algorithms based on machine learning (ML) techniques for diagnosis. As of today, no regulations specifying how these ML algorithms have to be applied, how their performance has to be measured or how their associated uncertainties have to be specified exist.

Aim At the core of this project stands the development of measures to quantify the uncertainties associated with ML algorithms applied to medical problems, in particular the analysis and processing of PPG signals. To achieve this the following tasks will be addressed: (i) benchmark datasets will be generated using publicly available in vivo, and synthetic data (ii) different ML models and uncertainty quantification (UQ) methods will be used to analyse the processing of the PPG signals and specify the associated uncertainty and (iii) a good practice guide with accompanying software repository showcasing the used models, methods and benchmarks will be developed and made publicly available.

Objectives

The overall objective is to provide trustworthy machine learning models for analysing photoplethysmography signals in a medical context, by developing methods for the quantification of uncertainty in supervised machine learning and deep learning models applied to photoplethysmography signals and generating reference datasets to benchmark those models, supported by software being developed that will be publicly available for independent review of the models.

The specific objectives are:

1. To develop methods for quantifying the uncertainty for at least 3 existing classification and 3 existing regression supervised machine learning and/or deep learning models using photoplethysmography (PPG) data, considering the effects of both aleatoric (data) uncertainty and epistemic (model) uncertainty on model predictions.

2. To generate at least 5 measurement problems and their corresponding 5 datasets, using real and/or synthetic photoplethysmography data, that can be used to benchmark accuracy and uncertainty of supervised machine learning and deep learning models. In addition, to make those reference problems and datasets available to the medical device and digital health communities via an online repository.

3. To validate the uncertainties obtained for existing machine learning and deep learning models of Objective 1 and to compare the accuracy and uncertainty of at least 3 classification and 3 regression machine learning

and/or deep learning models in order to identify models and methods which have high accuracy and low uncertainty for a wide range of tasks.

4. To engage with the medical device, digital and health communities to (a) promote the use of the good practice guide and the accompanying software repository through conference contributions, peer-reviewed journal articles and stakeholder workshops, (b) support the adoption of the benchmarking problems and datasets by providing guidelines for their use, and (c) develop a framework for independently reviewing machine learning models proposed by industry to assist them in getting regulatory approval.

5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (NMIs, DIs, medical device calibration services), standards developing organisations (IEC, ISO), and end users (clinical practitioners, digital experts within the health communities, manufacturers of medical and healthcare products).

The Consortium

The consortium brings together the leading European NMIs and DIs in the fields of Machine Learning, Uncertainty Quantification and Medical Imaging, and they are complemented by a number of leading research institutes and companies that bring their specific knowledge and experience. In total, 6 NMIs/DIs, 8 universities or research institutes and 2 companies are involved in the project.

Software Release v0.1

From the very beginning of the project one of the consortiums main goals has been to create a common software repository. As a general idea the software should satisfy two major needs. First, it should aid the documentation of all the scientific results obtained in the project, including scripts to recreate the exact experiments described in the good practice guide. This way it is easy for every potential user of the software to have an entry point into valid uncertainty quantification for machine learning in medical applications. Secondly, the software should be modularised and adhere to modern software development standards, as this provides the means to easily understand the package structure and allows for fast adaptation of the code by end users.

In February this year, the consortium release the first preliminary version v0.1 of the QUMPHY software repository. Even though this version does not have all the promised features built in yet, it gives a good glimpse into the structure, looks and future features of the project. You can give it a try anytime you want. Also, if anything bothers you while using the software, let us know by creating an issue or writing a short mail.

Engaging with the Community

The project focusses on connecting with both the scientific community and end-users to make sure it is on the right track with what the European community needs. To achieve this the consortium held two stakeholder workshops to keep everyone updated and obtain some feedback. The first one was on September 12th, 2023, where the consortium shared the project goals and strategies. Then, on April 23rd, 2024, the consortium organised another workshop to talk about the developed benchmark problems and datasets, making sure they are relevant to our target communities.

We've also been engaging with peers at various conferences, with a standout moment at the Computing in Cardiology 2024 conference. There, members of the consortium hosted a special session called "Open Questions in Open Research in Cardiovascular Data Science," featuring talks from both our team and external experts. It has been a fantastic opportunity to spark some discussions and get the scientific community really engaged with the project.

If you want to stay informed about the latest project results and join the conversation, you could check out our LinkedIn group!

Publications

Peer Reviewed Articles

[1] A. D. Rodway, L. Hanna, J. Harris, R. Jarrett, C. Allan, F. Pazos Casal, B. C. Field, M. B. Whyte, N. Ntagiantas, I. Walton, A. Pankhania, S. S. Skene, G. D. Maytham, and C. Heiss. "Prognostic and predictive value of ultrasound-based estimated ankle brachial pressure index at early follow-up after endovascular revascularization of chronic limb-threatening ischaemia: a prospective, single-centre, service evaluation". In: *eClinicalMedicine* 68 (02/2024), p. 102410. DOI: 10.1016/j.eclinm.2023.102410.

[2] M. Rinkevičius, J. Lázaro, E. Gil, P. Laguna, P. H. Charlton, R. Bailón, and V. Marozas. "Obstructive Sleep Apnea Characterization: A Multimodal Cross-Recurrence-Based Approach for Investigating Atrial Fibrillation". In: *IEEE Journal of Biomedical and Health Informatics* 28.10 (10/2024), pp. 6155–6167. DOI: 10.1109/jbhi.2024.3428845.

[3] L. Hanna, A. D. Rodway, P. Garcha, L. Maynard, J. Sivayogi, O. Schlager, J. Madaric, V. Boc, L. Busch, M. B. Whyte, S. S. Skene, J. Harris, and C. Heiss. "Safety and procedural success of daycase-based endovascular procedures in lower extremity arteries of patients with peripheral artery disease: a systematic review and meta-analysis". In: *eClinicalMedicine* 75 (09/2024), p. 102788. DOI: 10.1016/j.eclinm.2024.102788.

Proceedings & Other

[4] P. Charlton and P. A. Kyriacou. "Wearable Photoplethysmography: Current Status and Future Challenges". In: *2023 Computing in Cardiology Conference (CinC)*. CinC2023. Computing in Cardiology, 11/2023. DOI: 10.22489/cinc.2023.076.

[5] N. Strodthoff. “Open Science to Foster Progress in Automatic ECG Analysis: Status and Future Directions”. In: *2024 Computing in Cardiology Conference (CinC)*. Vol. 51. CinC2024. Computing in Cardiology, 12/2024. DOI: 10.22489/cinc.2024.057.

[6] M. Rinkevičius, P. H. Charlton, and V. Marozas. “Uncertainty in Photoplethysmography-Based Cuffless Blood Pressure Trend Monitoring: A Personalized Approach”. In: *2024 Computing in Cardiology Conference (CinC)*. Vol. 51. CinC2024. Computing in Cardiology, 12/2024. DOI: 10.22489/cinc.2024.098.

[7] C. A. Bench, N. Strodthoff, M. Moulaeifard, P. Aston, and A. J. Thompson. “Towards Trustworthy Atrial Fibrillation Classification from Wearables Data: Quantifying Model Uncertainty”. In: *2024 Computing in Cardiology Conference (CinC)*. Vol. 51. CinC2024. Computing in Cardiology, 12/2024. DOI: 10.22489/cinc.2024.068.

[8] P. Aston. “Does Skin Tone Affect Machine Learning Classification Accuracy Applied to Photoplethysmography Signals?” In: *2024 Computing in Cardiology Conference (CinC)*. Vol. 51. CinC2024. Computing in Cardiology, 12/2024. DOI: 10.22489/cinc.2024.038.

Preprints

[9] P. Charlton, V. Marozas, E. Mejía-Mejía, P. A. Kyriacou, and J. Mant. “Determinants of photoplethysmography signal quality at the wrist”. In: (10/2024). DOI: 10.36227/techrxiv.172954491.17588920/v1.

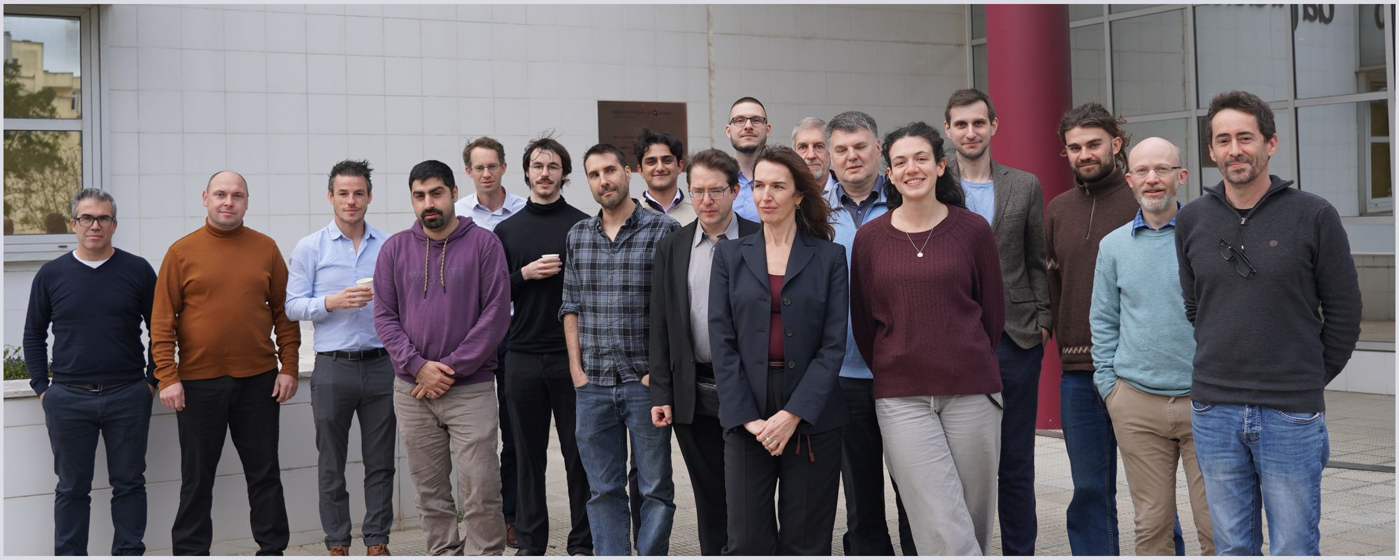
[10] M. Moulaeifard, L. Coquelin, M. Rinkevičius, A. Sološenko, O. Pfeffer, C. Bench, N. Hegemann, S. Vardanega, M. Nandi, J. Alastruey, C. Heiss, V. Marozas, A. Thompson, P. J. Aston, P. H. Charlton, and N. Strodthoff. *Machine-learning for photoplethysmography analysis: Benchmarking feature, image, and signal-based approaches*. 2025. arXiv: 2502.19949 [cs.LG].

[11] M. Moulaeifard, P. H. Charlton, and N. Strodthoff. *Generalizable deep learning for photoplethysmography–based blood pressure estimation – A Benchmarking Study*. 2025. arXiv: 2502.19167 [cs.LG].

That’s All

Thank you for reading. If you want to stay up-to-date with the project, you can always visit our project website:

www.qumphy.ptb.de



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