

Titre de la thèse/Thesis title : Application of multimodal LLM-based assessment in nephropathology for diagnosis and prognosis

Laboratoire d'accueil / Host Laboratory : Laboratoire d'Etude de l'Apprentissage et du Développement

Spécialité du doctorat préparé/Speciality : Informatique et Intelligence Artificielle

Mots-clefs / Keywords : Artificial Intelligence, LLM, embedded systems, nephropathology

Descriptif détaillé de la thèse / Job description

Renal pathology has a central role in the diagnosis and evaluation of the prognosis of many kidney diseases and in transplantation. Numerous studies have shown the decisive importance of quantifying the histological structures of biopsy sections. This sub-discipline of conventional histology is called morphometry [Asg23]. These structures can be very numerous and calculating the area, perimeter and/or radius they represent requires cutting out each structure, which is impossible to achieve in a reasonable time. In addition, the relatively high inter-pathologist variability makes this method less interesting. Thus, these markers are rarely used in practice. Artificial Intelligence (AI)-based automations have been developed to automate the recognition of normal and pathological renal histological structures, in particular through the collaboration of our Skinet team [Far23], [Jac23]. However, these studies are unimodal, in the sense that they only use biopsy images. The latest research in Artificial Intelligence (AI) and in particular in deep learning has led to the emergence of Transformers-type networks [Lin22] whose performance has revolutionized the field. These networks are the basis of next-generation image processing models (such as VisionTransformer) [Han23], but also of natural language processing (Large Language Model (LLM), extended language models) [Nav25]. These recent advances in AI make it possible to envisage multimodal studies by combining biopsy images and biological and clinical textual data. [Nam25] from a more general point of view, as well as [Ung25] and [Hu25] for nephrology in particular, have shown the interest, but also the challenges posed by such studies. In the context of the anatomical renal pathology mentioned above, the objective of the thesis is to combine these two types of models by first using the capabilities of LLMs to process biological and clinical data and produce representations that will serve as a context for the processing of biopsy images. Indeed, the provision of a context could make it possible to refine the predictions in an unprecedented way and get even closer to the approach of a specialized pathologist. The ultimate goal will be to move forward the model with a view to generalizing the methodology and use it "live" on microscopes using cameras.

Références bibliographiques / Bibliography

[Asg23] Asghar MS, et al. Morphometric analysis of chronicity on kidney biopsy: a useful prognostic exercise. Clin Kidney J 17: sfad226, 2024.

[Far23] Farhat, I., Maréchal, E., Calmo, D., Ansart, M., Painsavoine, M., Bard, P., Tarris, G., Ducloux, D., Felix, S. A., Martin, L., Tinel, C., Gibier, J.-B., Funes de la Vega, M., Rebibou, J.-M., Bamoulid, J., & Legendre, M. Recognition of intraglomerular histological features with Deep Learning in Protocol Transplant Biopsies and its Association with Kidney Function and Prognosis. Clinical Kidney Journal, 17(2), sfad019, 2023.

[Han23] Han, K., Wang, Y., Chen, H., Chen, X., Guo, J., Liu, Z., Tang, Y., Xiao, A., Xu, C., Xu, Y., Yang, Z., Zhang, Y., & Tao, D. (2023). A Survey on Vision Transformer. IEEE Transactions on Pattern Analysis and Machine Intelligence, 45(1), 87-110.

<https://doi.org/10.1109/TPAMI.2022.3152247>.

[Hu25] Hu, Y., Liu, J., & Jiang, W. (s. d.). Large language models in nephrology : Applications and challenges in chronic kidney disease management. Renal Failure, 47(1), 2555686.

<https://doi.org/10.1080/0886022X.2025.2555686>.

[Jac23] Jacq, A., Tarris, G., Jaugey, A., Paindavoine, M., Maréchal, E., Bard, P., Rebibou, J.-M., Ansart, M., Calmo, D., Bamoulid, J., Tinel, C., Ducloux, D., Crepin, T., Chabannes, M., Funes de la Vega, M., Felix, S., Martin, L., & Legendre, M. Automated Evaluation with Deep Learning of Total Interstitial Inflammation and Peritubular Capillaritis on Kidney Biopsies. Nephrology Dialysis Transplantation 38(12), 2786 - 2798, 2023.

[Lin22] Lin, T., Wang, Y., Liu, X., & Qiu, X. (2022). A survey of transformers. AI Open, 3, 111-132.

<https://doi.org/10.1016/j.aiopen.2022.10.001>.

[Nam25] Nam, Y., Kim, D. Y., Kyung, S., Seo, J., Song, J. M., Kwon, J., Kim, J., Jo, W., Park, H., Sung, J., Park, S., Kwon, H., Kwon, T., Kim, K., & Kim, N. (2025). Multimodal Large Language Models in Medical Imaging : Current State and Future Directions. Korean Journal of Radiology, 26(10), 900-923. <https://doi.org/10.3348/kjr.2025.0599>.

[Nav25] Naveed, H., Khan, A. U., Qiu, S., Saqib, M., Anwar, S., Usman, M., Akhtar, N., Barnes, N., & Mian, A. (2025). A Comprehensive Overview of Large Language Models. ACM Trans. Intell. Syst. Technol., 16(5), 106:1-106:72. <https://doi.org/10.1145/3744746>.

[Ung25] Unger, Z., Soffer, S., Efros, O., Chan, L., Klang, E., & Nadkarni, G. N. (2025). Clinical applications and limitations of large language models in nephrology : A systematic review. Clinical Kidney Journal, 18(9), sfaf243. <https://doi.org/10.1093/ckj/sfaf243>

Profil demandé / Applicant profile

The candidate is a Master's II student or a fifth-year engineering student. He or she has a triple major in mathematics, computer science, and data science.

Enthusiastic, dynamic, self-reliant, and a strong communicator, they know how to look beyond the surface and provide in-depth analyses. They remain unfazed by the inevitable technical challenges they encounter and are able to come up with innovative solutions.

Preferred selection criteria:

- Competencies
- Interpersonal Skills

Personal characteristics:

- Autonomy
- Dynamism
- Communicativity
- Creativity

Financement : Région BFC

Dossier à envoyer pour le **31 août 2026**

Début du contrat : 1^{er} Octobre 2026

Salaire mensuel brut : 2300€

Direction de la thèse:/ Thesis Supervisor

YANG-SONG Fan / fanyang@ube.fr

Encadrement de la thèse : co-directeur(s) et co-encadrant(s)

BARD Patrick / co-directeur

Applicants are invited to submit their application to the PhD supervisors.

Application must contain the following documents:

- CV
- Cover letter
- At least 1 reference letter