Interview with the first and the corresponding authors of the *RILEM Tech Lett* paper "Heritage ++, a Spatial Computing approach to Heritage Conservation"

Yamini Patankar and Dr Robert Flatt, respectively PhD student and Full Professor at the Institute for Building Materials, Physical Chemistry of Building Materials, ETH Zurich, Switzerland, are the first and corresponding author of the paper "Heritage++, a Spatial Computing approach to Heritage Conservation", published by *RILEM Technical Letters* in January 2025. This interview offers a behind-the-scenes view of the paper.


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Heritage ++, a Spatial Computing approach to Heritage Conservation

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Dr Daniela Ciancio - RILEM Implementation Manager (RIM): It is nice to see you again, Robert and Yamini! Last time we met, in Mendrisio, Switzerland, during the 2025 RILEM Spring Convention, you were very busy inviting the delegates to try a virtual tour of the Lausanne Cathedral! I have to confess that I was reluctant to try the tour, as I was afraid to embarrass myself in front of everyone… I had never tried a Virtual Reality (VR) headset before, but in the end, it was so easy and intuitive! It was a fantastic "hands-on" experience of the technologies that you presented in your *RILEM Technical Letters* paper. Could you tell us more about the content of your paper, please, and maybe make a comparison with similar technologies used nowadays, for instance, in medicine?

On the left: Prof. Flatt presenting the keynote lecture "Augmented infrastructure condition diagnosis – from bridges to cathedrals" at the 2025 RILEM Spring Convention in March 2025. On the right: delegates of the 2025 RILEM Spring Convention trying the tool Heritage++ with Virtual Reality (VR) headset. Images courtesy of D. Ciancio.

Yamini Patankar (Yamini): So, in this letter, we talk about the potential of spatial computing in the preservation of built heritage, while focusing on a select few technologies being used

in Heritage++. These include extended reality, artificial intelligence (mainly large language models (LLM) pipelines with Retrieval-Augmented Generation (RAG)), 3D modelling, and HBIM (Heritage Building Information Modeling) software. Starting with “eXtended Reality” (XR), it is an umbrella term which combines the whole spectrum, going from “reality” to “virtuality”, and includes Augmented Reality, Mixed Reality, Virtual Reality… so any point in the middle will be encompassed by this broader term. In the approach that we propose in this letter, we interact with digital data in the real world. In the case of the Lausanne cathedral, you could use a simple smartphone-based application to interact with the cathedral (which is the real object) and the information, which is a digital object in your phone. Or if you use one of those mixed reality goggles, like the one you tried in Mendrisio, you will deal with some digital information together with the context and real space: we think this approach could be really helpful to solve a lot of challenges which come with heritage preservation. To draw comparisons with medicine, extended reality has been used for training medical students and to perform surgical simulations for training purposes; virtual reality has also been explored for applications in psychological therapy, to treat anxiety or pain.

RIM: Wow! I didn't know about this.

Yamini: Beyond the possibility of XR to add information in our devices or fields of view, there is also the possibility of interacting with them. This has a large development potential, building on LLM pipelines with RAG. Large Language Models are very good at capturing, processing and answering back in human language. They perform very well if you want to query a huge database or summarise something specific from a large database, which happens a lot in the field of heritage preservation, where you have years and years of documentation, with data in different formats (could be images, videos, reports, papers, drawings). I think AI tools and LLM can greatly help experts to structure and summarise this data, and to make correlations.

Similarly, in the case of healthcare, AI can help experts in analysing images or X-rays. I recently read that they are now able to detect abnormalities in X-rays, and, of course, it's a very good tool to get the targeted information from existing literature. That being said, of course, it needs an expert to operate it, so they can verify the information. Finally, HBIMs act as a digital twin, a great tool to store geometric data linked with other information. By integrating these with LLMs, we can transfer large amounts of data, which is unorganised, into an organised structure (we call “information”). The approach here would overcome the challenges which come with HBIM platforms, enhancing their usability and efficiency with artificial intelligence and augmented/virtual reality tools.

Prof. Robert Flatt (Robert): Maybe I can add some things. I think the future and the really not too distant future we're looking at is the emergence of what we would call “helpful AI” combined with XR devices. These lightweight extended reality devices, which will probably very soon be relatively normal-weight glasses, might make, for example, smartphones obsolete. Anticipating this appears to be a very big driver for big tech to advance on this front. In this respect, the relatively recent TED Talk “The Next Computer? Your Glasses” by Shahram Izadi from Google is well worth watching.

What we present in our letter is the possibility of such devices to overlay information in our fields of view, making information retrieval much easier and intuitive. We show how they can

deliver information at moments that are critical in decision making and when normally you would not have access to that data: if you imagine somebody on a scaffolding of a cathedral, and there's a question they need to look up in a report, they're not going to pull up the laptop and be able to discuss that together with two other experts that are also up on the top of the cathedral on a rainy and windy day; but they could all be able to call up that information through vocal commands, and visualize it through their augmented glasses, hold on to the barrier, not fall down and actually have a high quality and content driven discussion on site among each other with a focus on finding a real solution.

RIM: Would the discussion be with real people, or with AI, as Yamini was talking about extracting meaningful information from a very big database?

Robert: It is both! You can have a discussion among experts on site that might require pre-selected information delivered to them by an AI tool which could be addressed as a “virtual expert”: but it would not be so much a virtual expert capable of taking decisions in the type of complex, multimodal environments of, let's say, preservation heritage, or health and environment. A pure AI device would a priori not be able to react to lots of soft and/or qualitative factors that are very important to human perception. We imagine these devices rather as tools supporting experts through their ability to feed in quantitative information at the right time. So, for Heritage++, these devices would exploit the ability of AI to provide you extra information, smartly preselected for you, but you, as the expert, remain the person deciding, and the person discussing key issues with other experts. You enhance your ability to better convey complex information, using more intuitive ways to communicate with experts in other subfields of the domain. For example, how does a material scientist communicate something to a structural engineer, and an architect to an art historian in an effective way on the scaffolding of the cathedral? How could they do this when the best way might be to show a specific plot, but you cannot easily pull it up there and share on your laptop? Alternatively, you might want to overlay on parts of the monument graphical representations of the consequences of specific interventions. This opens up completely new possibilities for communicating technical content among specialists from different domains.

RIM: In the letter, you say that this is not the first time that such an approach has been used, and that unfortunately, this initiative remains rather localised. Do you think you might have overcome this problem?

Yamini: There is a contextual nature which comes with problems of heritage preservation: the material used, the climatic conditions, the geography, the history, the culture… everything is so highly contextual that the solutions also tend to be specific and that causes a lot of workflows to be localised and it cannot be replicated or scaled up or applied to other cases. Along with that, another limitation comes up with the complexity of the interfaces of HBIM platforms, and this causes a lack of intuitive access to the information. So, the way we're working with Heritage++ is that while addressing a specific monument and challenges that come with it, we are developing broader workflows focusing on the longer term, with a degree of continuity in the input of data sets.

RIM: Robert, would you like to add something on this matter?

Robert: Yes! You know… the work is still very much in progress. I think one originality is to try to focus our efforts on the things we feel more comfortable with, concerning conservation and material questions and structure. To start from there, there would be other approaches that might be more, maybe art-oriented, historical and so forth. As an example, in Mendrisio, you tried the goggles where you can interrogate the stone, and that was done with the controller in your hand. Now, only a few months later, you can click on it with your hands in the air.

Beyond this, what we also see with these tools is the ability to better reach out to the public; for example, the app you tried about looking at the different stones is in the process of being transferred to something you can download on a phone or tablet, so somebody visiting the cathedral can start to have extra insight and they can also see what has been done to maintain this heritage. In our opinion, one of the greatest challenges in the preservation of heritage is that a good job is not a visible job. It is a great paradox, and we think that XR can contribute to better informing the public of the invaluable work done by the many stakeholders involved in conservation process. We're trying to do a bit of that with the Cathedral of Lausanne, which will have its 750th anniversary of the inauguration in October, and we're putting up a special interactive platform for this.

RIM: Nice! In your paper, you mention *"… the need to identify, organise and formalise the intuition of experts in this field and further enhance it through improved accessibility and interaction with the available critical data*". Will AI replace the "experts" one day? In other words, do you think that the figure of the person that have years and years of experience will disappear one day, replaced by a machine?

Robert: I think we obviously have to be very careful. Our general approach, and this is beyond just Heritage++, is to keep the human in the centre. I think that contrasts a lot with the way big tech currently approaches problems, because for entertainment, for business, it's rather making people more passive. But I think there are new ways to be found where you keep the human in the centre, and hopefully that actually becomes a new paradigm for big tech because somehow, they realise that you cannot deliver the best solutions alone, but ideally you want to get people to start thinking more critically while using those tools. Now… how this really happens is the challenging question. I think tools as Heritage++ have a huge potential to facilitate and accelerate knowledge transfer from an expert to an apprentice. We actually have a term to define this, and that is "Domain Expert 2.0". Yamini has a paper that she's submitted to a conference proceeding…maybe you want to comment about it?

Yamini: The challenges in heritage conservation can be considered as "wicked problems" which need qualitative and quantitative approaches altogether, and experts can tackle them by balancing these two aspects. This is why expert intuition is very crucial in the entire process. Rather than AI replacing this, the objective is for these tools to enhance humans' ability to handle complex situations, to provide us the right information at the right time so we can make the right decisions. As Robert said, the expert/human should always remain at the centre!

Robert: The construction has this history of the "master apprentice", the "compagnon" in French (*Editor's note: "compagnonage" refers to a traditional system of knowledge*

transmission and training for a trade, rooted in communities of "compagnons"). It's really interesting to imagine how this personalised relation is getting lost, but maybe there's a way of using these technologies to bring it back in a new form. You can also imagine how experts can train people in other locations through these tools. There is an argument that AI will not necessarily replace humans, but that humans who know how to best use AI will replace those who don't.

RIM: Yamini, what is your background? Are you an engineer?

Yamini: I've done my bachelor's in Architecture and master's in Architectural Conservation.

RIM: And you, Robert?

Robert: I did my undergrad at EPFL in a kind of a mixture between Chemistry and Chemical Engineering. Then I did my PhD in Material Science, also at EPFL.

RIM: I'm asking this because you talk about the "multidisciplinary" aspects in heritage conservation, but this also apply to your paper authored by 14 people, from departments of Architecture, Digital Building Technologies, Computational Design Lab, Earth Sciences, Physical Chemistry, etc… Can you tell us more about the writing of this paper, combining skills of people from so many different backgrounds?

Robert: For her PhD studies, Yamini applied for the Swiss Government Excellence Scholarship. It is a highly competitive process, evaluating both the quality of the proposal and of the applicant. Yamini's proposal about Heritage++ was great, and she had a very strong dossier, having had her Undergraduate Thesis ranked by the COA National Awards for Excellence in Architectural Thesis for 2020 amongst the top 10 in all India. For her to work on this project required she had to learn a lot about computer science and acquire the skills in these technologies. The topic of this paper very much emerged from this and the numerous interactions she curated, defining a vision that she began to lay out with her Scholarship.

RIM: Thank you again for sharing your stories and your views today. Good luck with the celebration of the Lausanne Cathedral in October this year!