VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Diana Sousa Gomes**

The public defense will take place on **Friday 3rd October 2025 at 5 pm** in room **D.2.01** (Building D, VUB Main Campus)

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ENHANCING REPRESENTATION LEARNING WITH GRAPH NEURAL NETWORKS BY UNDERSTANDING THEIR BENEFITS AND LIMITATIONS

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Abstract of the PhD research

Graphs - structures of points linked by relationships - are everywhere: in social media, transportation systems, biology, and more. Graph Neural Networks (GNNs) are a new kind of artificial intelligence designed to learn from these complex connections. But despite their popularity, we still do not fully understand when they work best or why they sometimes fail.

This dissertation takes a closer look at how GNNs actually learn. It shows that their success depends on the delicate balance between the information in the graph's connections and the data attached to its points. We introduce new tools to separate and measure these two factors, revealing situations where simpler methods can outperform even the most advanced GNNs. The common belief that "deeper" networks are always better is also challenged, and we demonstrate that adding layers often adds noise instead of insight.

By identifying these limitations and offering practical guidelines for designing GNNs, this work helps researchers and engineers build models that are not just more powerful, but also more reliable and efficient - paving the way for smarter AI systems that can handle the complex relational problems that shape our world.