Foundation Models: From Current Developments, Challenges, and Risks to Future Opportunities

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***Abstract*— We extensively review state-of-the-art foundation models in various fields such as LLMs, GPT, BERT, CLIP, etc. We also demonstrate some famous areas where foundation models are gaining much popularity, such as general foundation models, foundation models in the medical domain, education, law and finance, mathematics, autonomous driving, etc. These foundation models are trained on large-scale data by leveraging the capabilities of self-supervised learning approaches that ensure outperforming accuracy for relevant downstream tasks. They are successful due to pioneering architectural innovations, especially synergistically interleaving transformers and convolutional neural networks. These models have exhibited adaptability and resilience in various data patterns and conditions through sophisticated training paradigms such as self-supervised and supervised learning methods. While they hold transformative potential, they also have many challenges. The scale and quality of training data are still important predictors of model performance, and the need for interpretable and explainable AI systems becomes critically important. We highlight important research opportunities, high-performing computationally efficient and scalable architectures, and approaches to enable multimodal learning capacities. This review sheds light on the current state of foundation models and proposes a roadmap for their successful transitions.**

***Keyword*— Foundation models, self-supervised learning, vision-language models, LLMs, digital pathology foundation models.**

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