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Data-driven soft sensors in blast furnace ironmaking: a survey

Key words: Soft sensors; Data-driven modeling; Machine learning; Deep learning; Blast furnace; Ironmaking process

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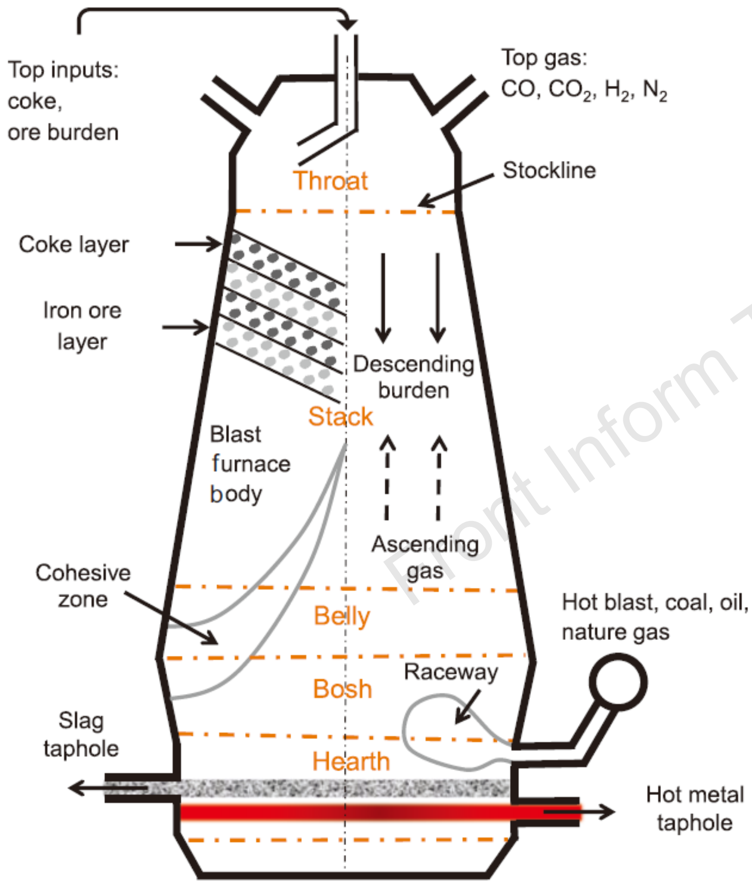
Motivation

- With the acceleration of the carbon neutrality target, green intelligent manufacturing has become an inevitable trend in the development of the manufacturing industry.
- Iron and steel manufacturing occupies a pivotal position in the industrial field, and blast furnace ironmaking is one of the most energy consuming processes in the iron and steel industry [1].
- Therefore, iron and steel enterprises urgently need stable and efficient intelligent operations in the ironmaking process to achieve the goal of producing better-quality, low-carbon, green, and sustainable products.

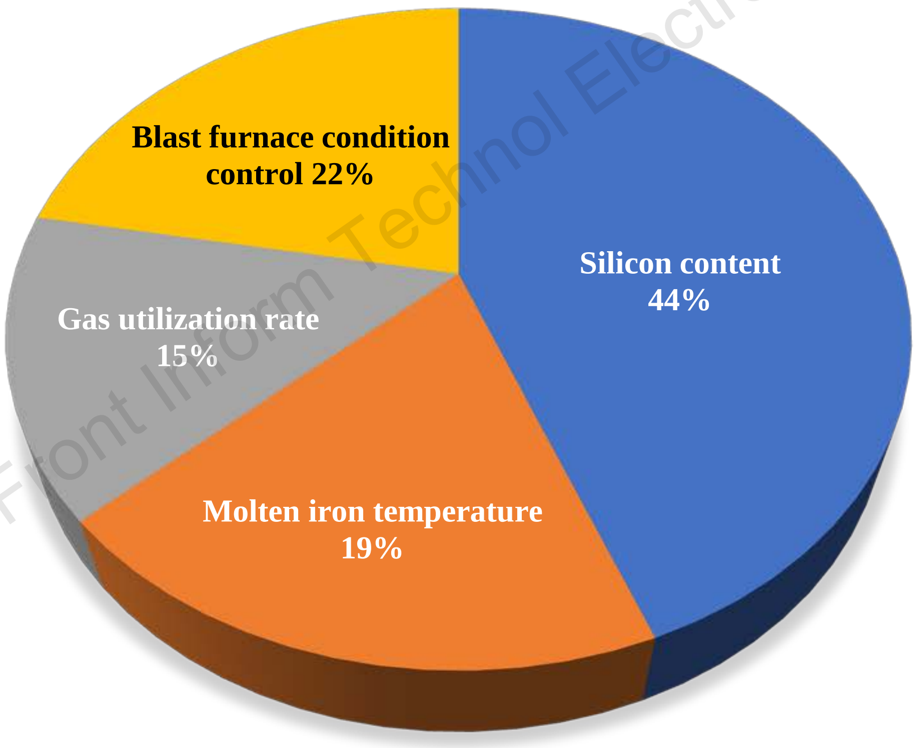
Background

- The majority of the world's steel is extracted from iron ores, and blast furnace ironmaking is a key stage in the process [2]. The whole structure of the blast furnace is depicted as follows:



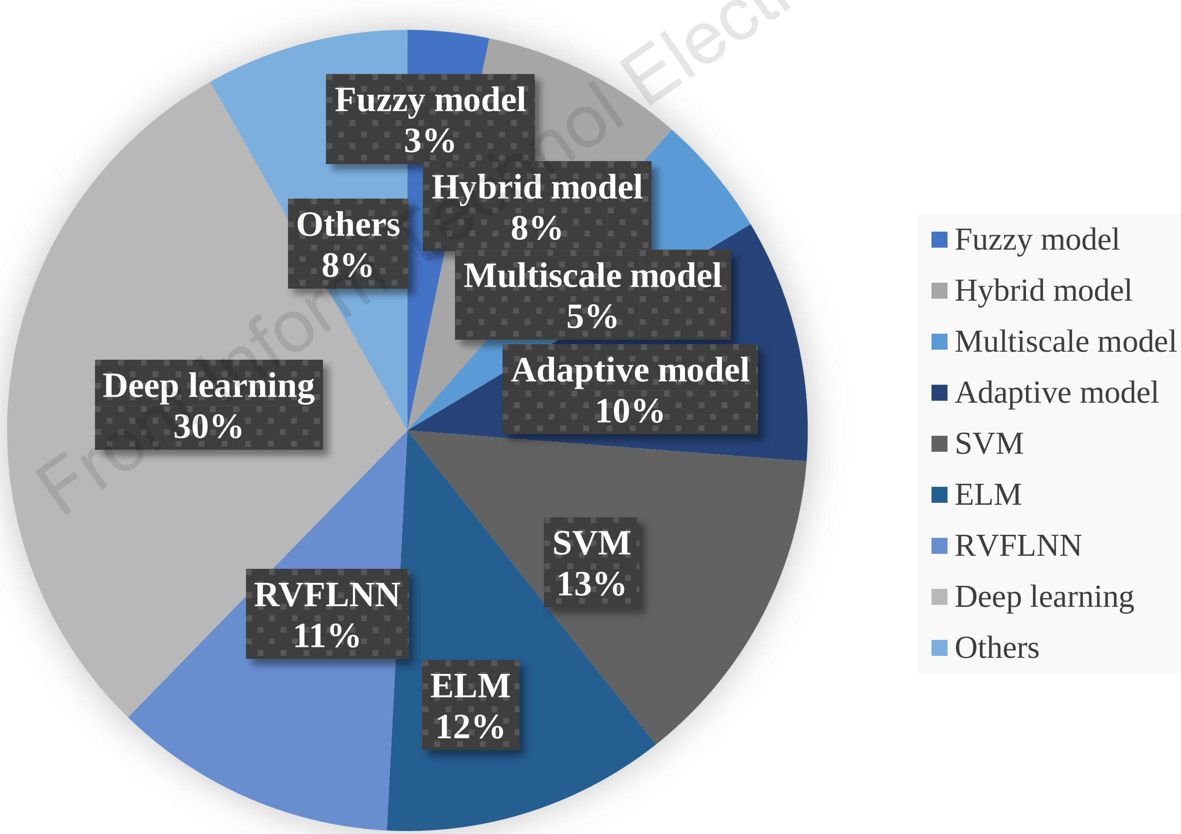
Application areas

- Typical application areas of data-driven soft sensors in blast furnace ironmaking are classified as follows: silicon content prediction and tendency forecasting, molten iron temperature prediction, gas utilization rate (GUR) prediction, and control of the blast furnace condition.



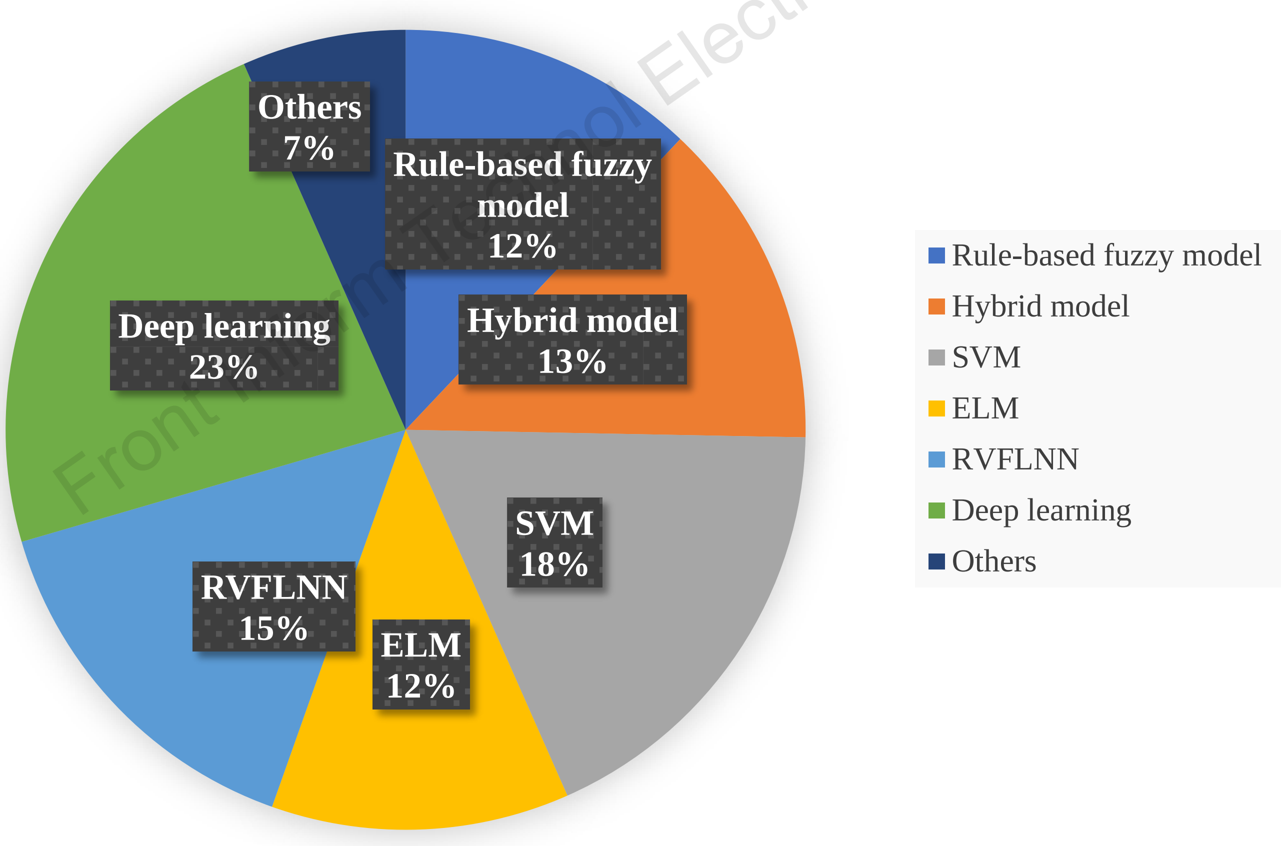
Application areas

- Silicon content is a key parameter in blast furnace ironmaking, serving as an essential indicator of the heat of the molten iron. Accurate prediction of silicon content can aid in optimizing the blast furnace process and achieving high-quality output, making it an important consideration for ironmaking operations [3].



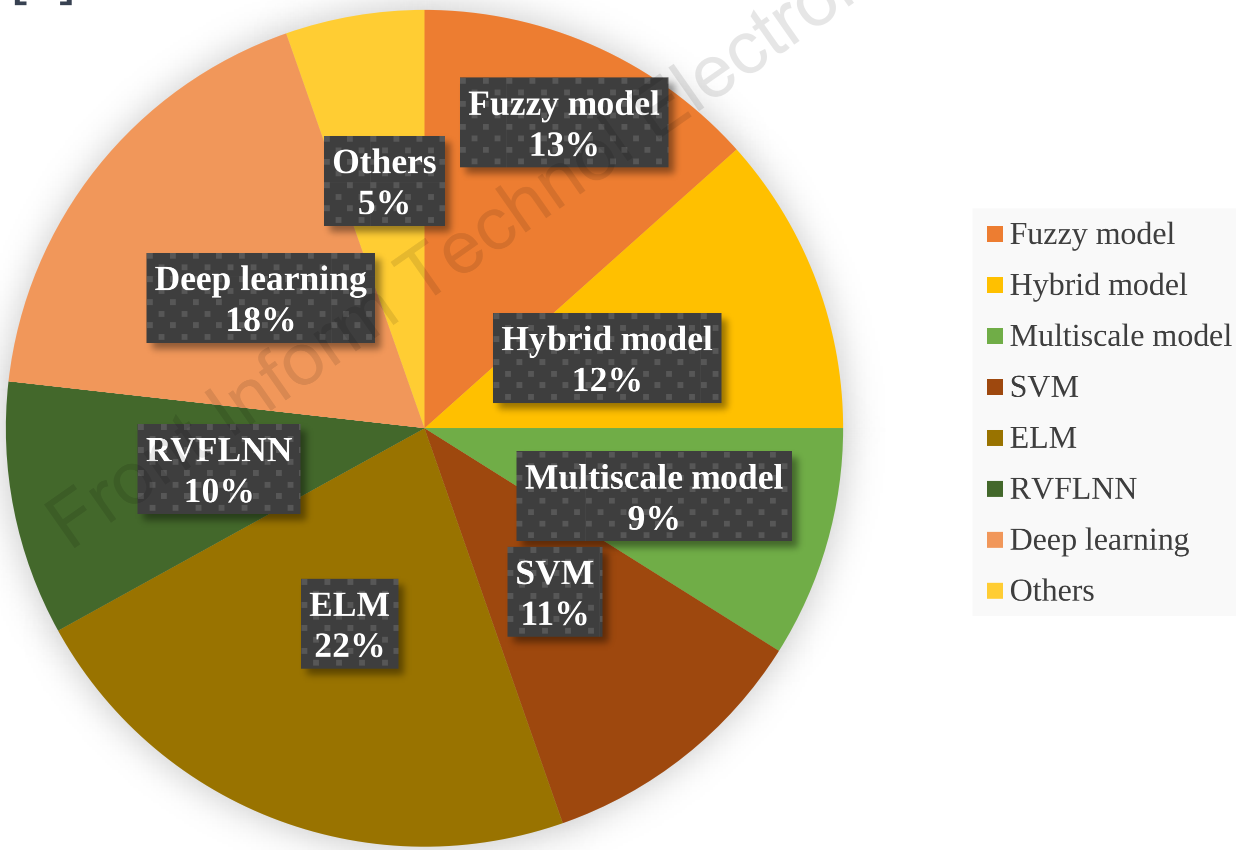
Application areas

- Temperature of molten iron is a critical parameter in blast furnace ironmaking, as it provides valuable insight into the thermal state of the blast furnace [4]. As such, accurate prediction and control of molten iron temperature is vital to ensure optimal conditions for the ironmaking process.



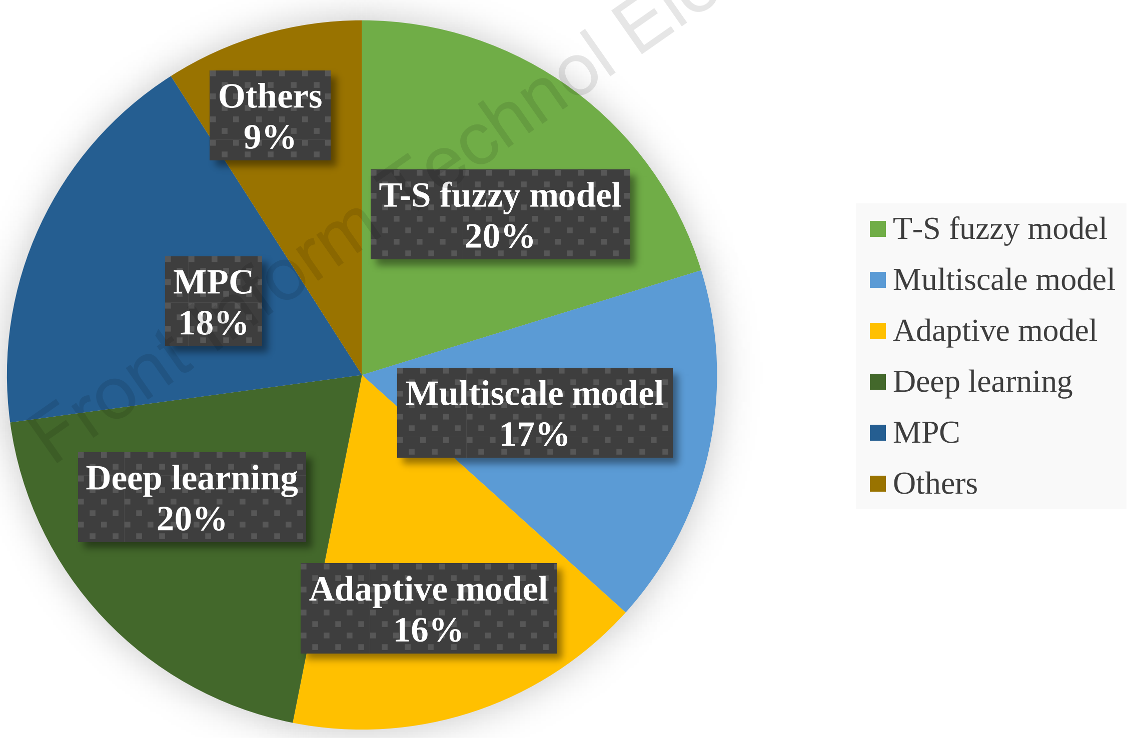
Application areas

- GUR is the ratio of the carbon dioxide content to the total carbon monoxide and carbon dioxide content in the top gas flow. A high GUR is indicative of adequate coal burning and reduced consumption, which is crucial for achieving optimal blast furnace performance [5].



Application areas

- Blast furnace condition control is a critical aspect of blast furnace ironmaking, typically focused on ensuring that the final molten iron quality (MIQ) meets the desired specifications [6]. Achieving optimal MIQ requires careful monitoring and control of various parameters, such as temperature, chemistry, and gas flow, throughout the ironmaking process.



Prospects

- Multi-source data fusion [7]
- Digital twin modeling [8]
- Parallel and distributed modeling
- Carbon neutrality

Summary

- This paper aims to provide an overview of data-driven soft sensing techniques for blast furnace ironmaking. By reviewing the state-of-the-art data-driven soft sensing algorithms in blast furnace ironmaking, it can be confirmed that data-driven soft sensors have great potential for academic research and industrial applications.

- This survey will motivate more researchers to strive to overcome the above challenges of soft sensing technology for blast furnace ironmaking. In the next decade and beyond, it is expected that more innovative ideas and more advanced soft sensing technologies will be developed and applied to solve various problems in blast furnace ironmaking.

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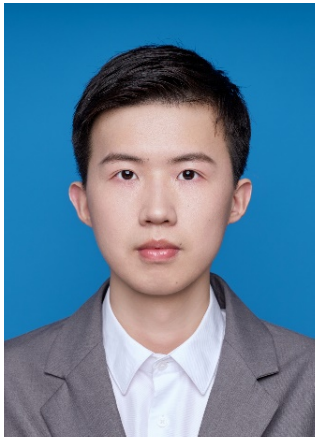

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