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Transformer in reinforcement learning for decision-making: a survey

Key words: Transformer; Reinforcement learning; Decision-making; Deep neural network; Multi-agent reinforcement learning; Meta-reinforcement learning

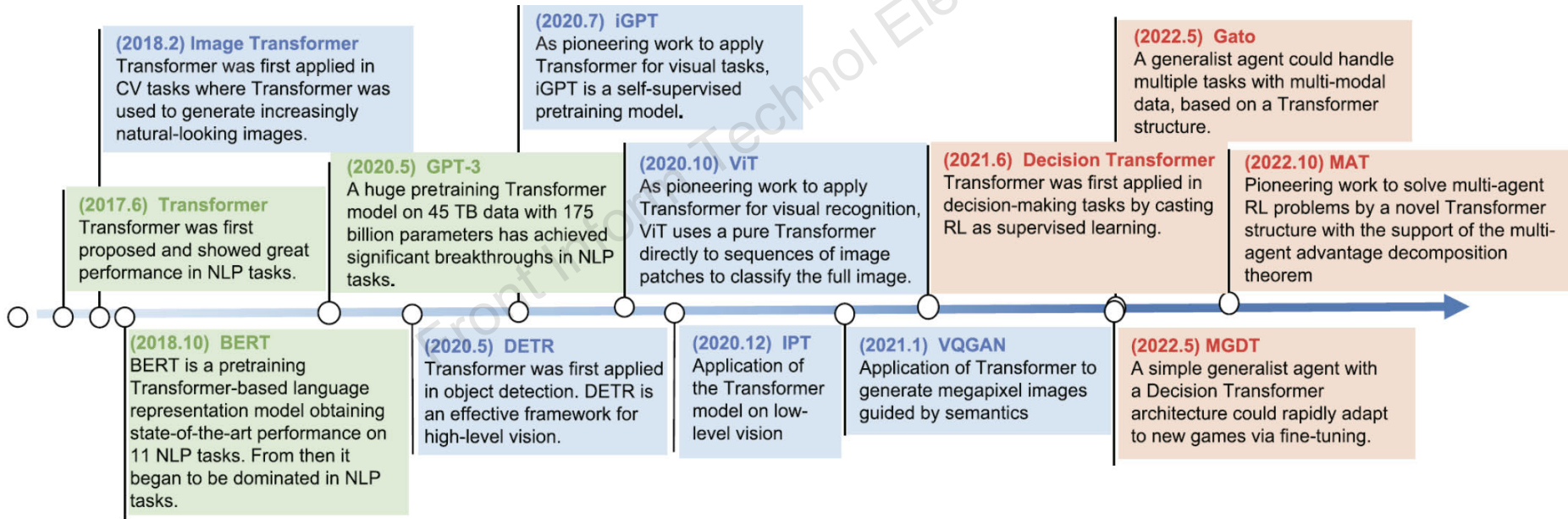
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Transformer development

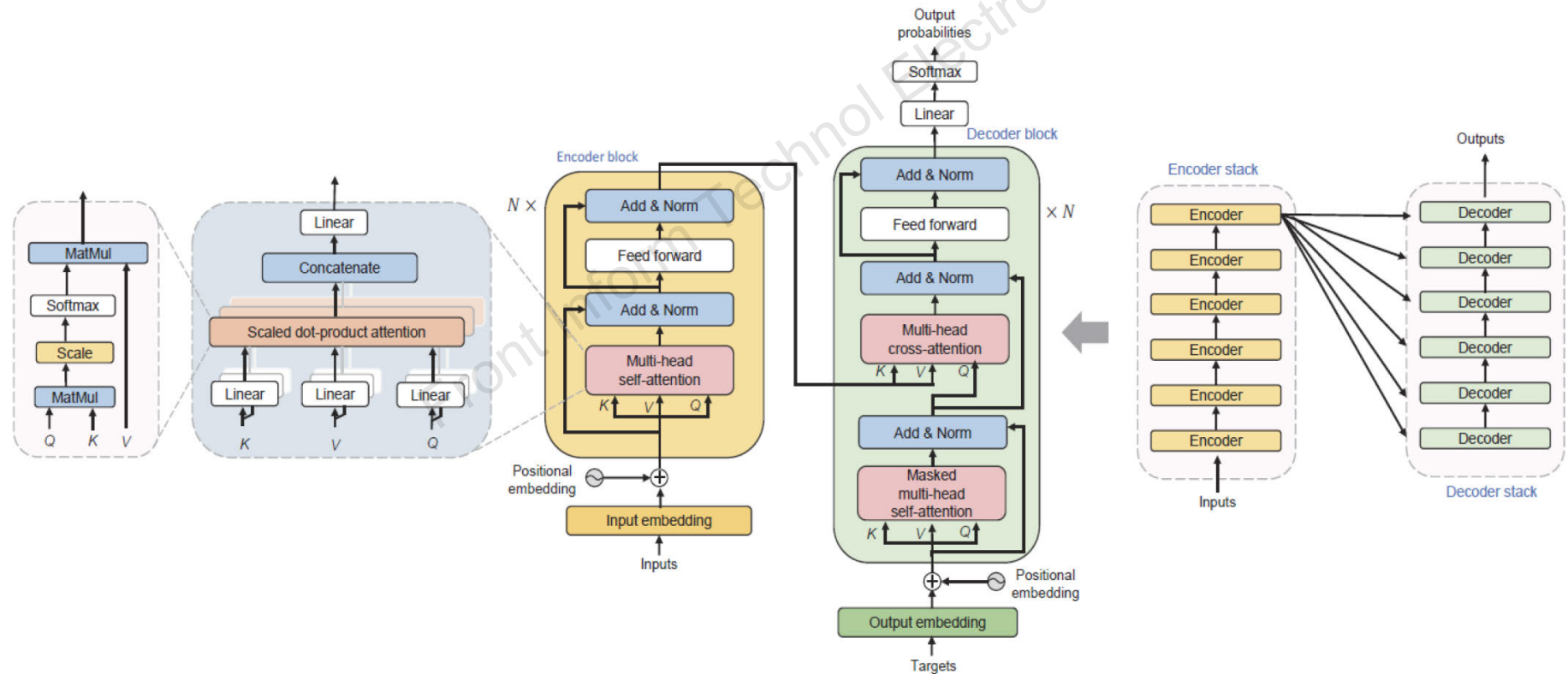
- Inspired by Transformer's major success in the fields of computer vision (CV) and natural language processing (NLP), researchers have made efforts to explore the benefit of Transformer models in solving **decision-making (DM)** tasks [1-3].



Milestones in the development of Transformer

Transformer structure

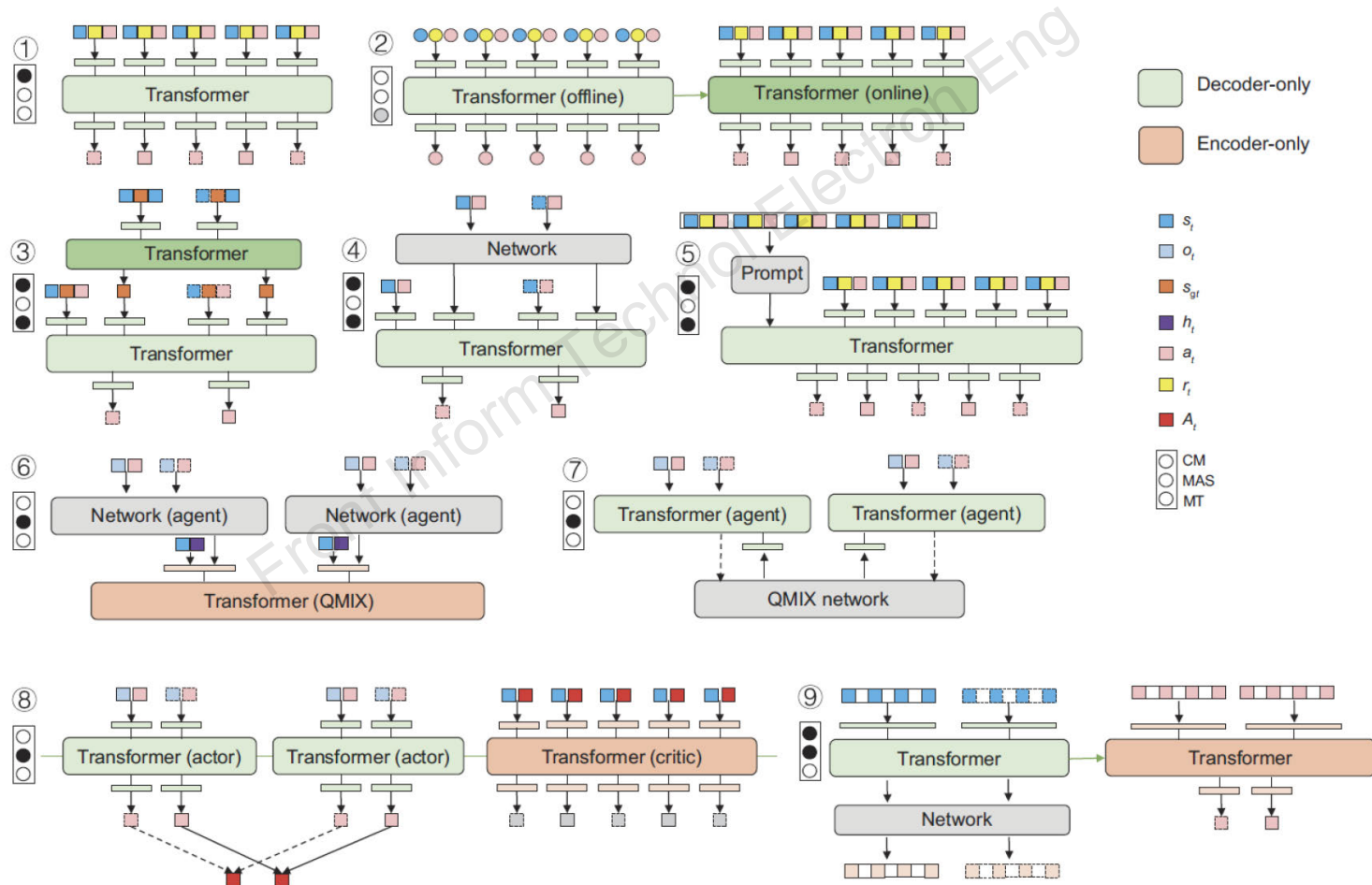
- Transformer [4] is a new kind of neural architecture that sequentially encodes the input sequence as powerful features via the **attention mechanism** and generates an output sequence after the final encoder output is passed in parallel to a stack of decoders.



Structure of Transformer [4, 5]

Transformer-based RL methods

- We provide insights into the advantages and disadvantages of combining Transformer with various RL tasks, such as offline RL, online RL, hierarchical RL, meta-RL, and multi-agent RL (MARL).

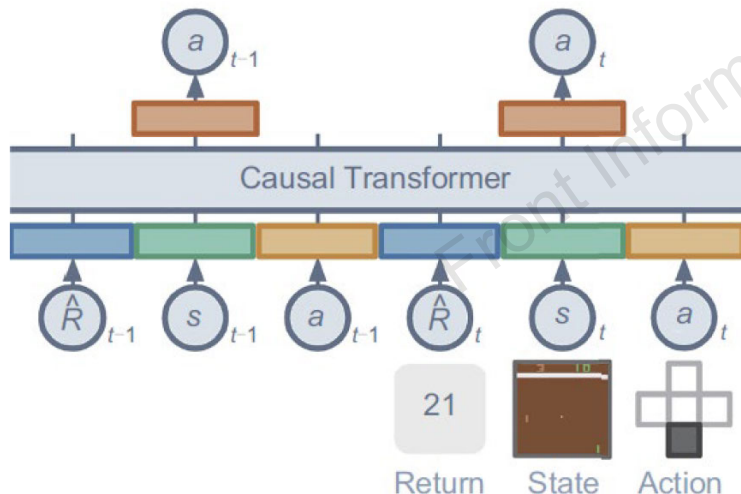


Typical TransRL frameworks

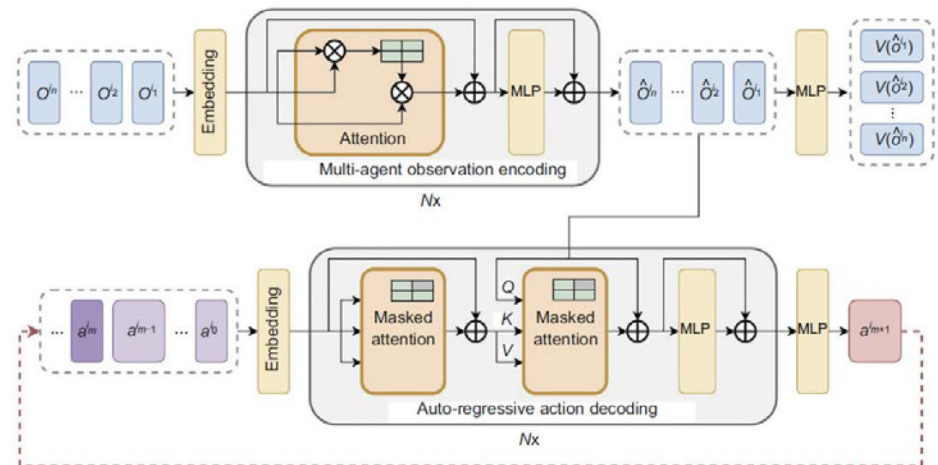
Representative TransRL models

□ We provide insights into the details of three representative implementation instances of TransRL models and discuss their characteristics, benefits, and limits.

- Decision Transformer [6]
- Multi-agent Transformer [7]
- Gato [8]



Decision Transformer [6]



Multi-agent Transformer [7]

Applications

- ❑ TransRL has been exploited in gaming AI, robotics, transportation, and computer systems.
- ❑ We summarize the applications of TransRL in video games, robotic manipulation, robotic navigation, autonomous driving, and combinational optimization.

Domain	RL	TransRL
Gaming AI	• Board games • Card games • Video games	• Video games (open-ended games)
Robotics	• Sim-to-real • Control	• Robotic manipulation • Robotic navigation
Transportation	• Traffic control	• Autonomous driving
Computer systems	• Resource assignment • Security	• Combinatorial optimization

Challenges and open problems

❑ Stability and structure optimization

->Further improvements

- Theoretical analysis of TransRL ability
- Global interaction mechanism design

❑ Expensive memory and computation

->Further improvements

- Search-based neural network structure design
- Automated model compression

❑ Stochastic effectiveness

->Further improvements

- TransRL mechanism design for the stochastic environment

We summarize the latest papers and their open-source implementations at <https://github.com/williamyuanv0/Transformer-in-Reinforcement-Learning-for-Decision-Making-A-Survey>

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