

Augmentative Topology Agents For Open-Ended Learning

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Introduction to Open-Ended Learning

- What is Open-Ended Learning?
 - Agents' behaviour to progressively learn through divergence.
 - Evolving endlessly.
- Current State-of-the-art:
 - Paired Open-Ended Trailblazer (POET) [1].
 - Enhanced POET (EPOET) [2].
 - ACCEL [3].
 - XLand [4].
 - MineDojo [5].



[1] R. Wang, J. Lehman, J. Clune, and K. O. Stanley, "Paired open-ended trailblazer (POET): Endlessly generating increasingly complex and diverse learning environments and their solutions," arXiv preprint arXiv:1901.01753, 2019.

[2] R. Wang, J. Lehman, A. Rawal, J. Zhi, Y. Li, J. Clune, and K. Stanley, "Enhanced POET: Openended reinforcement learning through unbounded invention of learning challenges and their solutions," in International Conference on Machine Learning, 2020, pp. 9940–9951.

Motivation For Our Work

- Fixed topology leads to limitations in learning complex tasks.
- None of the previous works address the issue.
- Two components to truly Open-Ended Learning:
 - a. Environments
 - b. Agents

[3] J. Parker-Holder, M. Jiang, M. Dennis, M. Samvelyan, J. Foerster, E. Grefenstette, and T. Rocktäschel, "Evolving curricula with regret-based environment design," arXiv preprint arXiv:2203.01302, 2022.

[4] O. E. L. Team, A. Stooke, A. Mahajan, C. Barros, C. Deck, J. Bauer, J. Sygnowski, M. Trebacz, M. Jaderberg, M. Mathieu et al., "Open-ended learning leads to generally capable agents," arXiv preprint arXiv:2107.12808, 2021.

[5] L. Fan, G. Wang, Y. Jiang, A. Mandelkar, Y. Yang, H. Zhu, A. Tang, D.-A. Huang, Y. Zhu, and A. Anandkumar, "Minedojo: Building open-ended embodied agents with internet-scale knowledge," arXiv preprint arXiv:2206.08853, 2022.



Augmentative Topology Enhanced POET (ATEP)

- Two changes to EPOET:
 - a. Use of NEAT to augment topology of agents.
 - b. Transfer mechanisms
 - Fitness-Based ATEP
 - Species-Based ATEP



Transfer Mechanisms

- Fitness-Based Transfer (FBT-ATEP)
 - Inspired by EPOET transfer mechanism.
 - Compare fitness of best genome from candidate population with best genomes from 5 previous generations of target population.
 - If greater than all 5 previous scores, we finetune the best genome on target environment and compare with the best of the 5 previous best genomes.
 - If passed, we replace candidate population with target population.



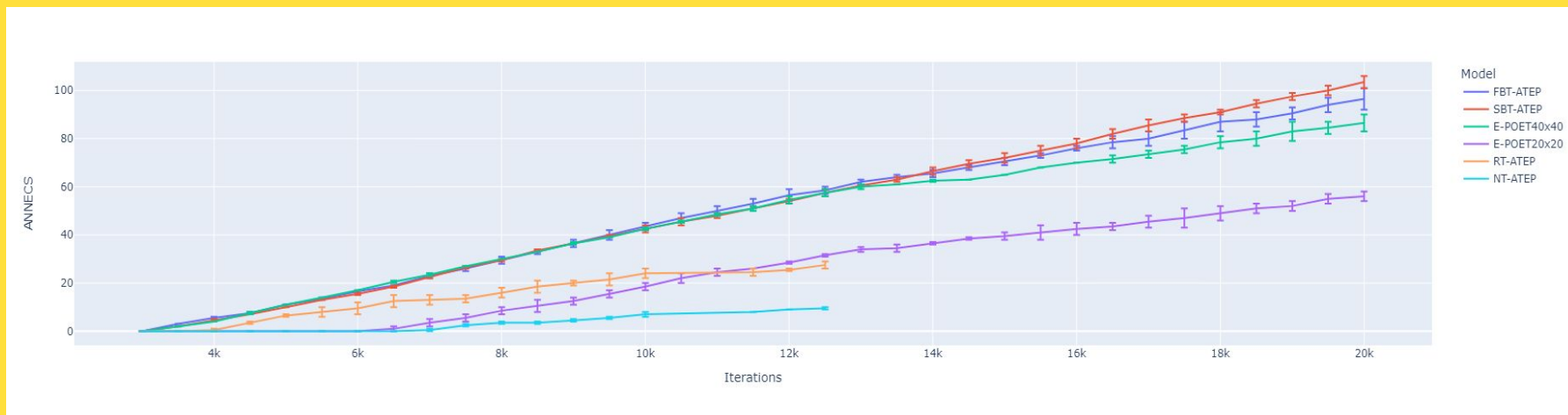
Transfer Mechanisms

- Species-Based Transfer (SBT-ATEP)
 - We take the best genome of candidate population and find delta value.
 - We see across all populations if their best genome is within the delta threshold with candidate best genome.
 - If so, we only transfer best genomes' species and replace it with only target genomes' species.



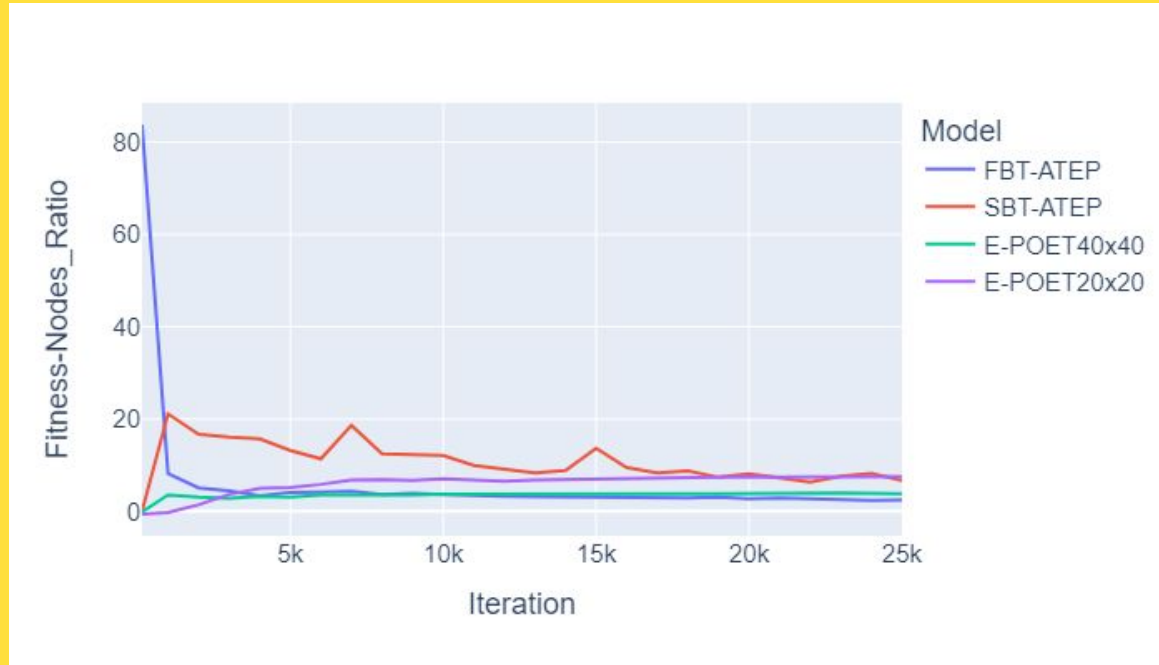
Results

- Open-Endedness:



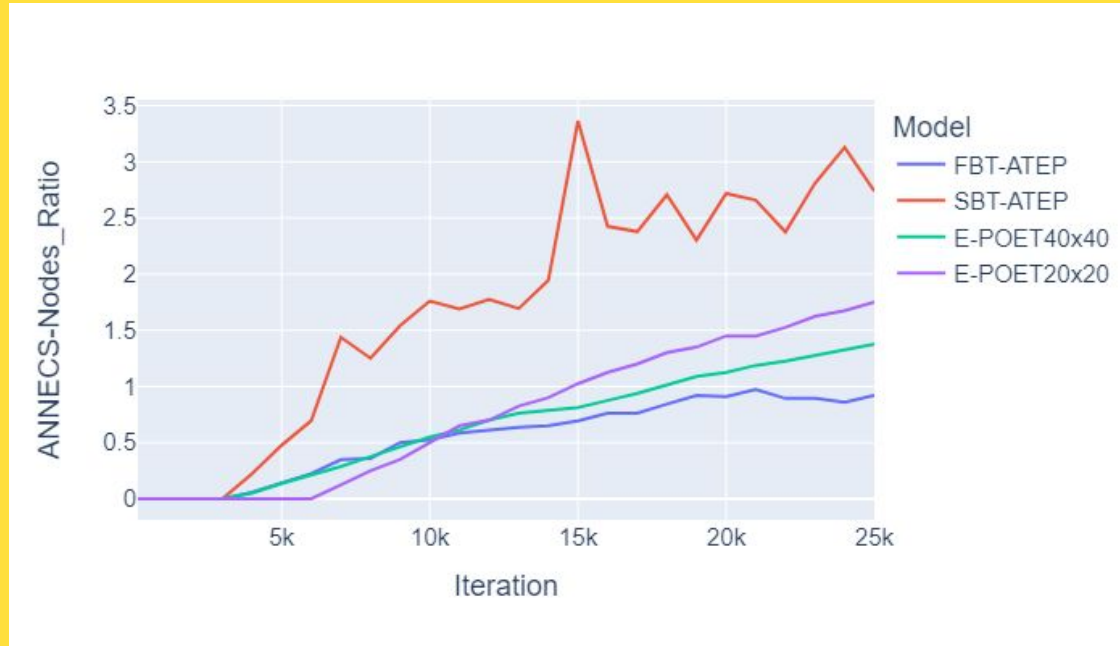
Results

- Node explorations analysis:



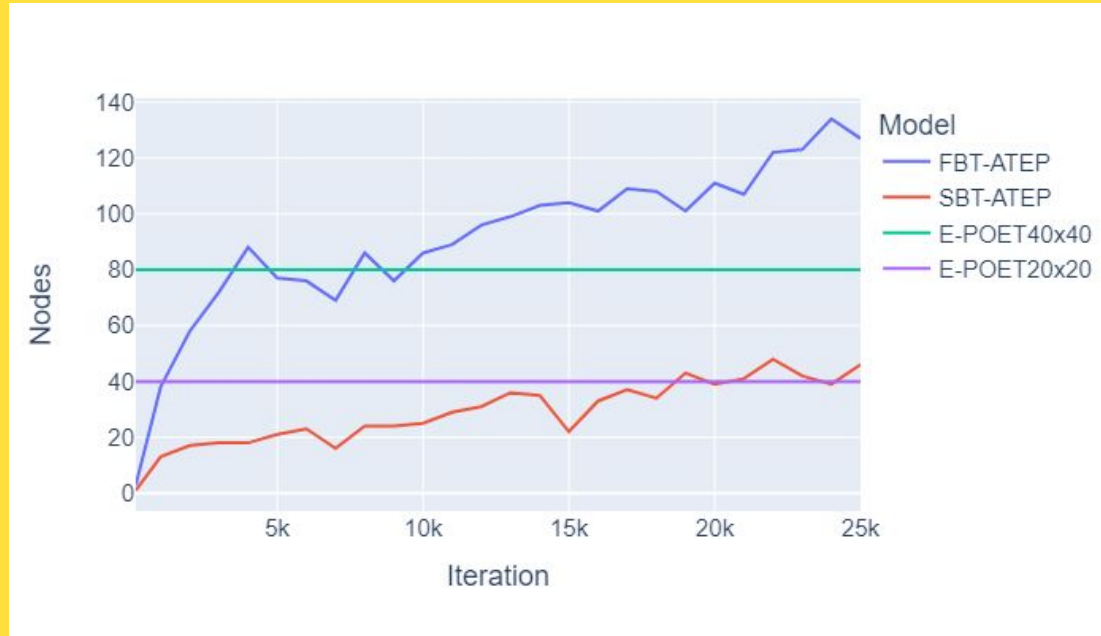
Results

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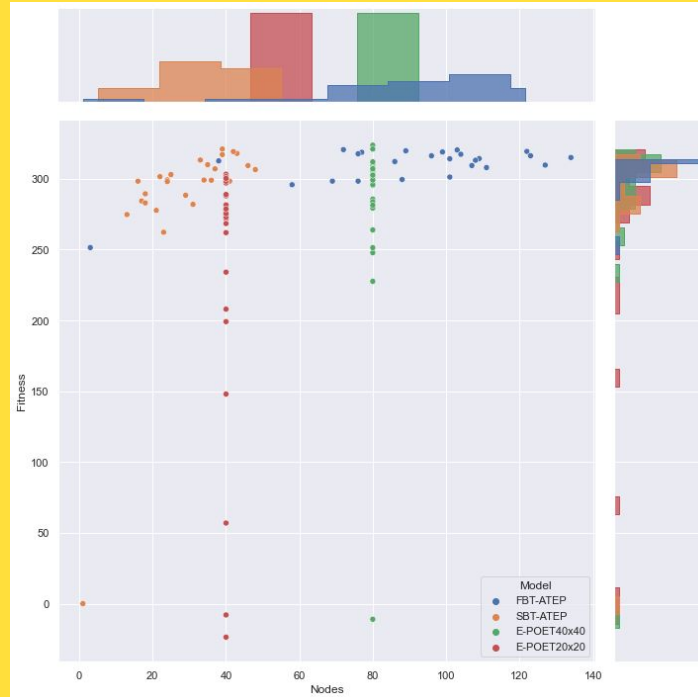
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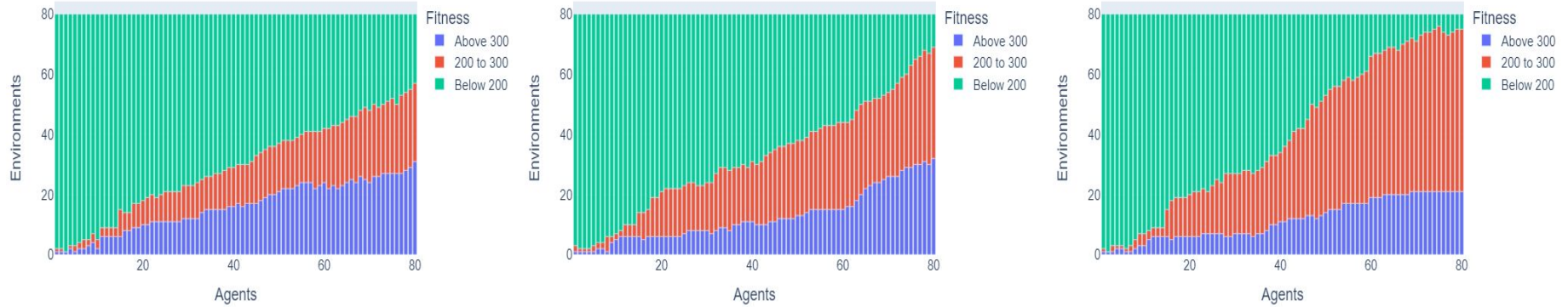
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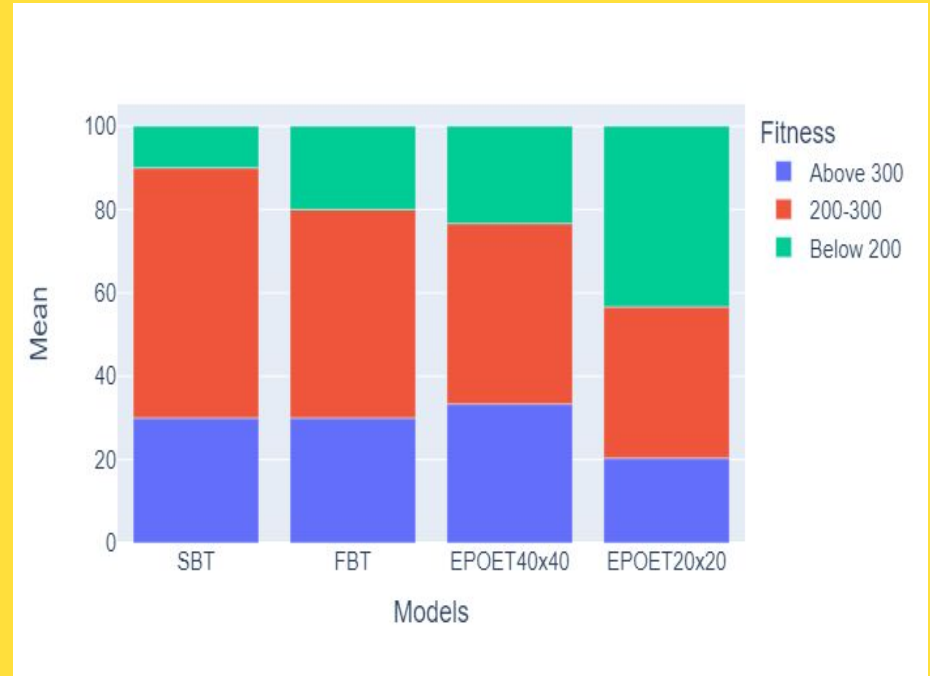
Results

- Generalization Ability on self created environments:



Results

- Generalization on others' environments.



Conclusion and Future Works

- Empirically showed that ATEP outperforms EPOET due to augmentative topology.
- More Open-Ended and generalized agents.
- Exploring Quality Diversity algorithms
- Exploring more transfer mechanisms.
- Researching on more environments.



Thank you!

