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Bipartite Graph Learning for Autonomous Task-to-Sensor Optimization

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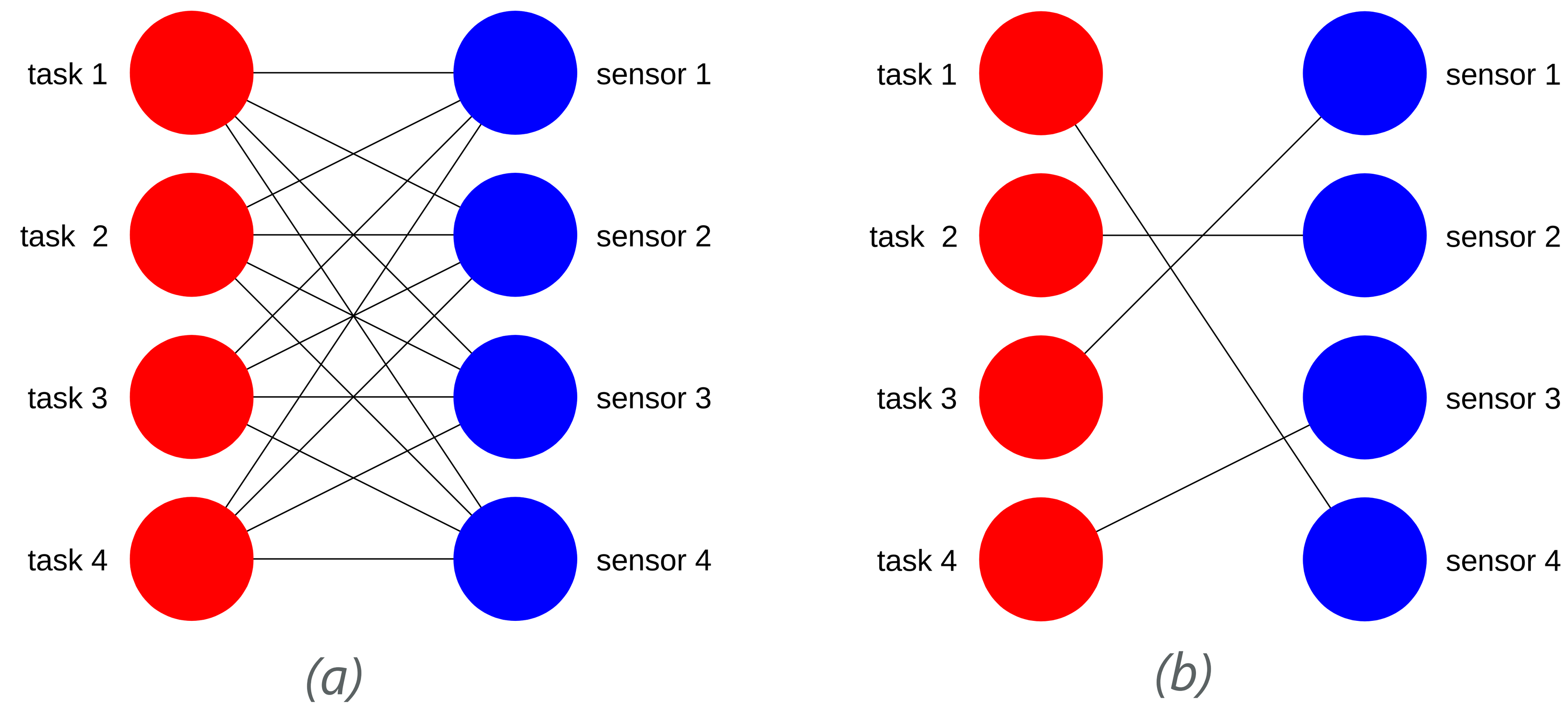
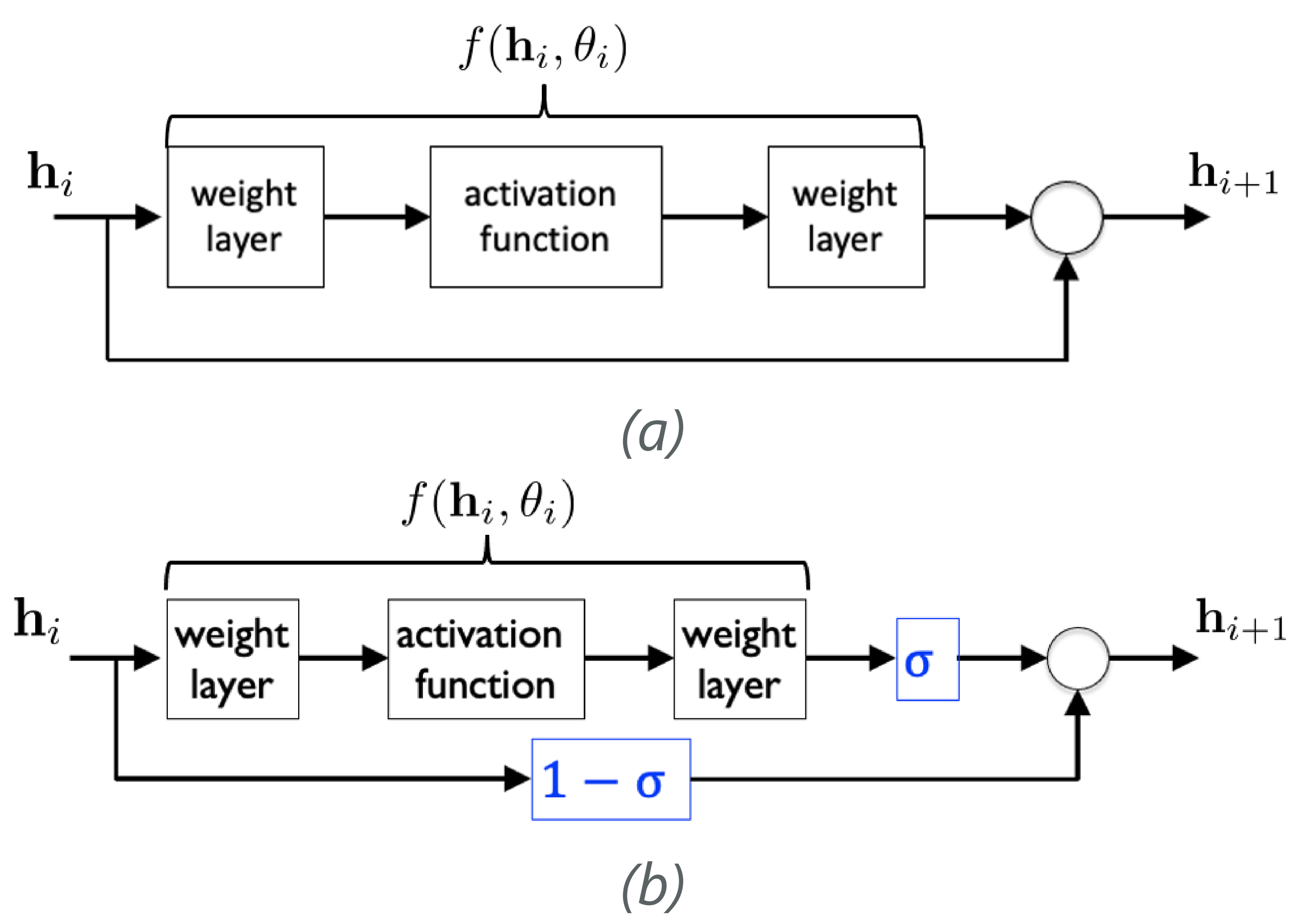
Background/Objective

- The concept of a bipartite graph provides a mathematical framework for task-to-sensor mapping by establishing connectivity between various high-level tasks and the specific sensors and/or processes that must be invoked to fulfil the task requirements.
- This project studies how machine learning can be used to perform autonomous bipartite matching for task-to-sensor optimization.
- The results can be applied for various DoD applications including joint targeting and fires.



Task-to-sensor allocation can be posed as a bipartite graph matching problem (a) where the goal is to match each task to a sensor in a way that minimizes cost or maximizes value (b).



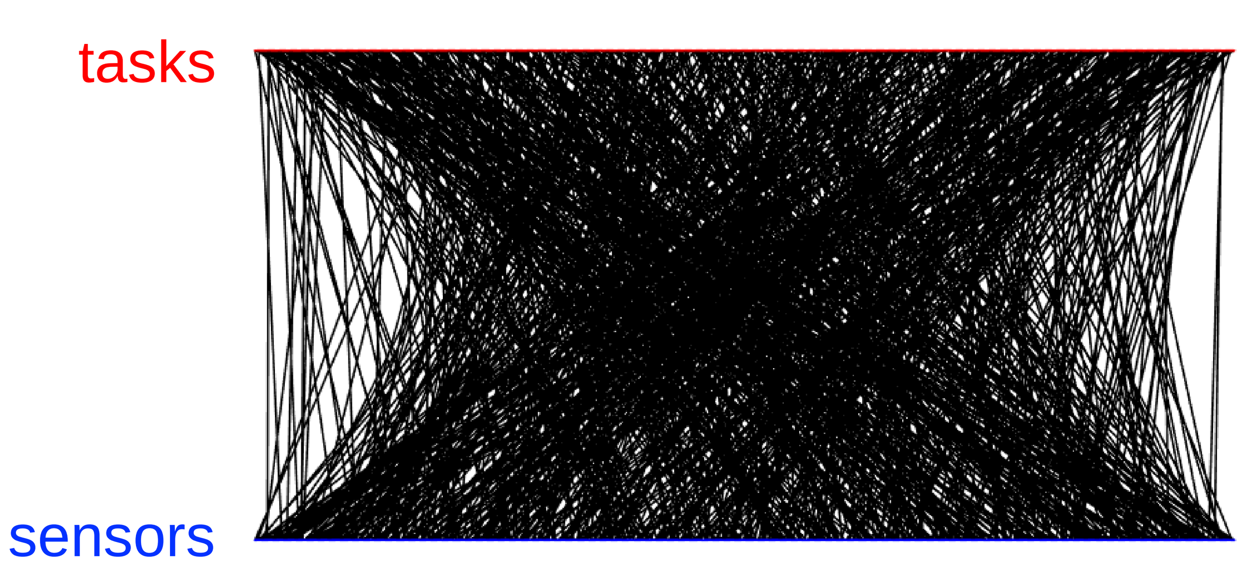
Conventional residual network layer (a) and the 'weighted residual' network layer (b) used for solving bipartite matching problems

Network Architecture

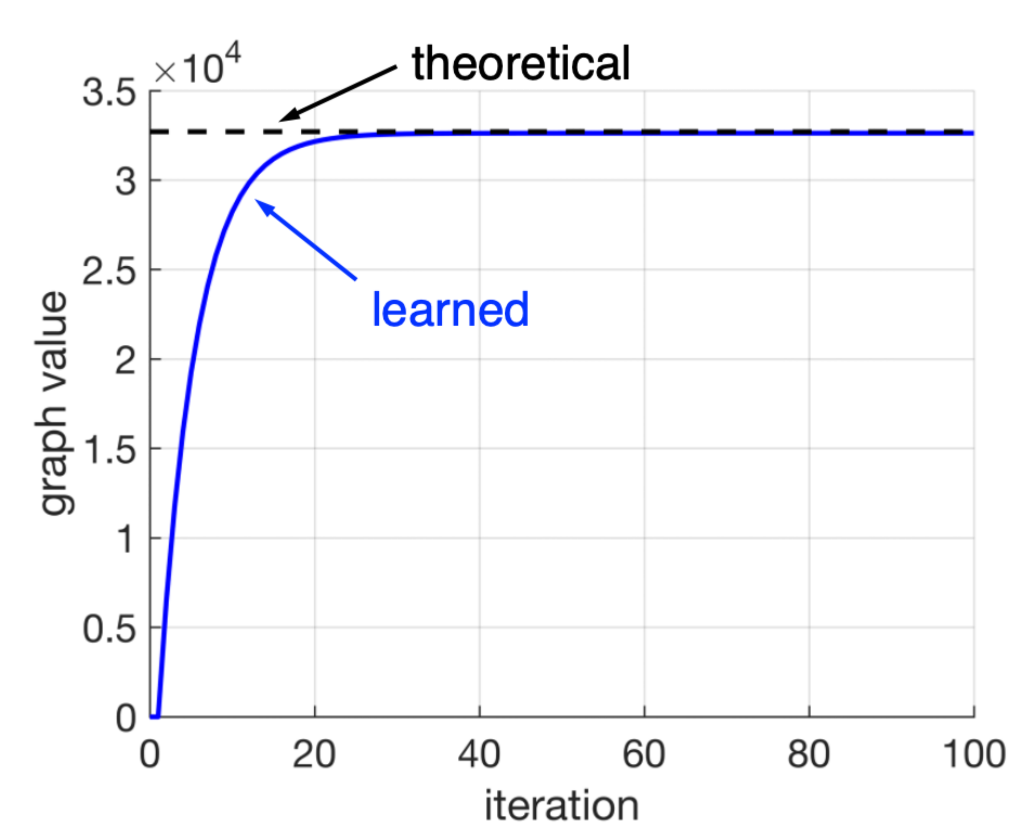
- A deep network of *weighted residual* layers was studied for solving the bipartite graph problem.
- A conventional residual network, uses 'skip' connections to add the input of a layer together with its output. By weighting the skip connection, the feedforward term can be modulated to influence the signal evolution within the network equations to solve the matching problem
- The proposed architecture can be used for finding minimum cost or maximum value mappings (depending on the objective of the user)

Example Results

- The machine learning-based approach is scalable to large problem sets



Example bipartite matching solution for n=m=800 (left) and the evolution of the 'learned' graph value (right)



Conclusion

- This study shows that machine learning concepts can be used to autonomously perform bipartite matching for task-to-sensor planning/optimization problems.
- As the state of knowledge evolves, the approach can be used to periodically and rapidly re-solve allocation problems to reflect changes in resource availability and/or task completion.

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