

STAR TRACK

Generating sufficient training data

Satellite Navigation with Machine Learning

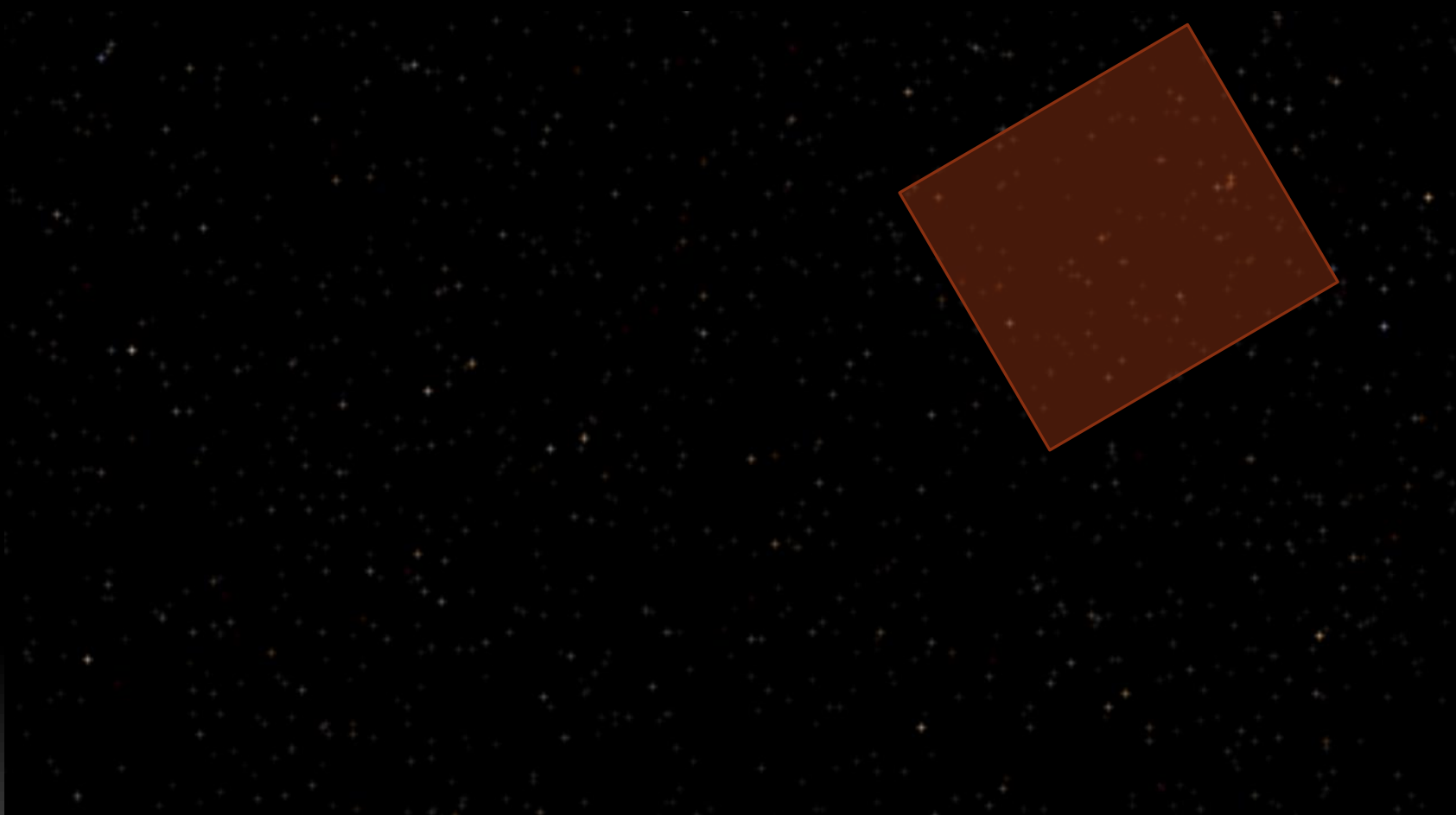
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Problem Motivation

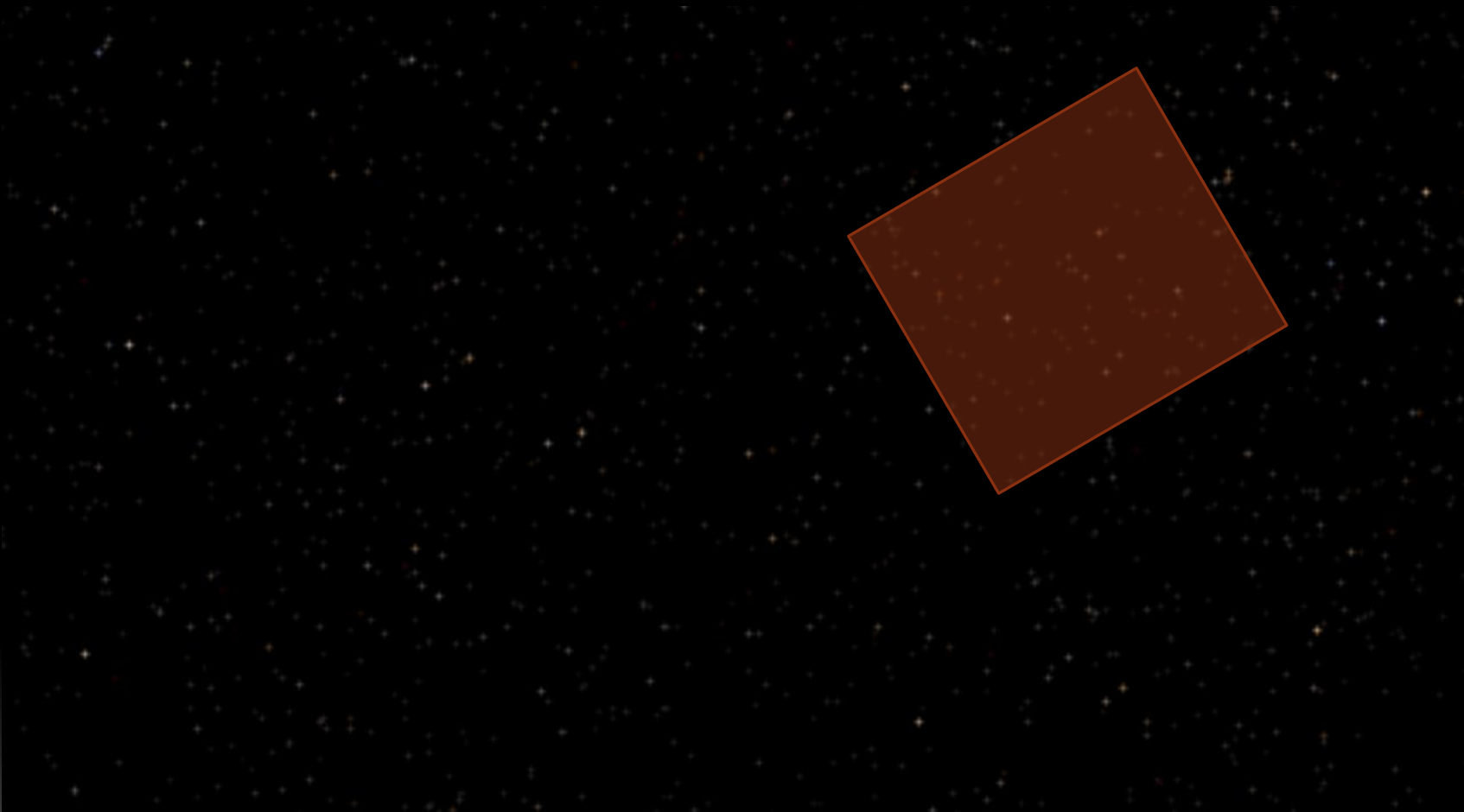
- Extremely accurate and consistent for “lost in space” problem
- Inexpensive star tracking systems at least \$100,000
- Limited modern research in ML applications to star tracking (Hong et. al. 2000, Trask 2002, Li et. al. 2003)

Star Tracking



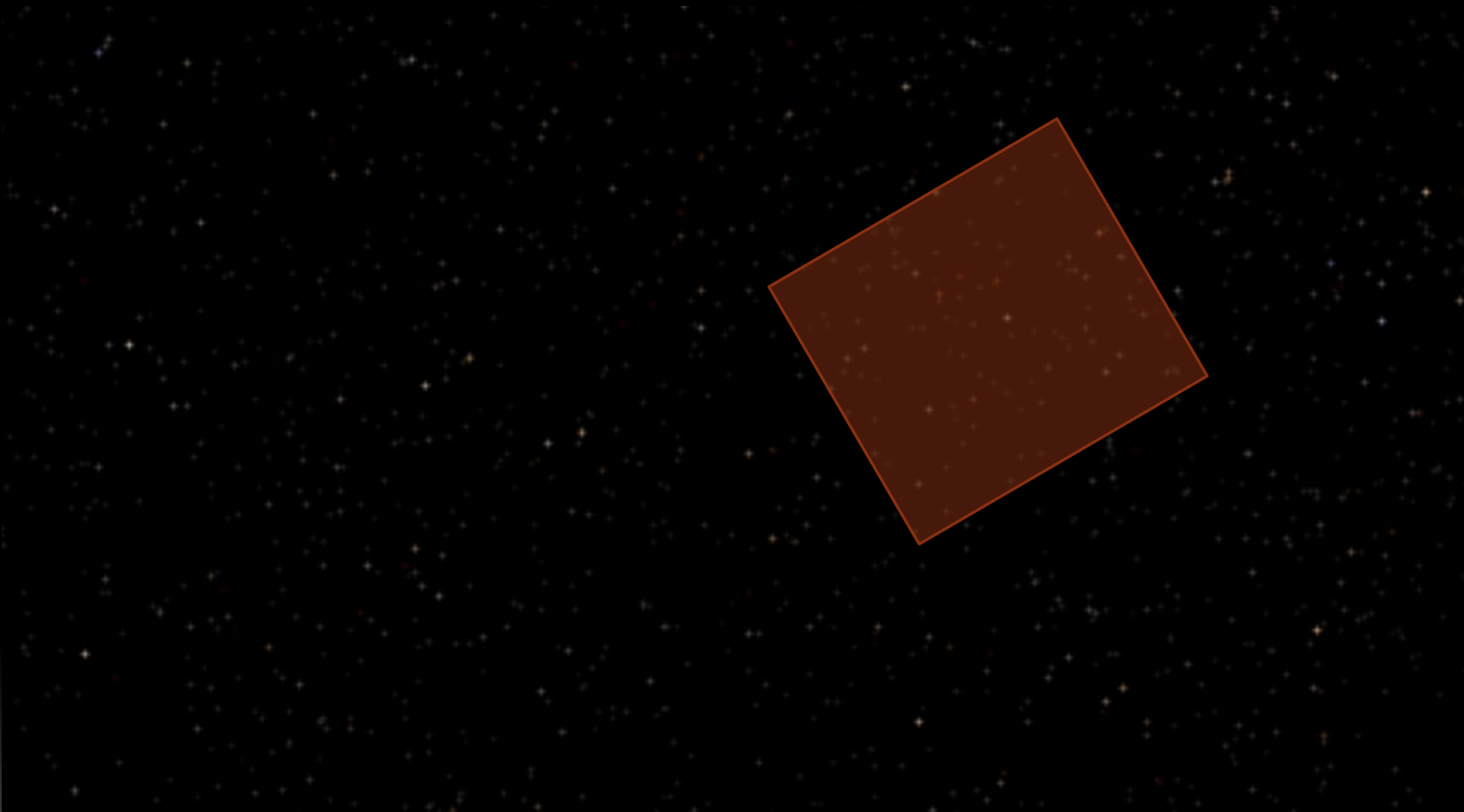
Source: Tycho Sky Map
<https://svs.gsfc.nasa.gov/3572>
Not to scale

Star Tracking



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Not to scale

Tycho Skymap

- 384 MB image of the celestial sphere
- Generated by data from the Tycho satellite mission



Simulation $t = 0$ sec



Simulation $t = 5 \text{ sec}$



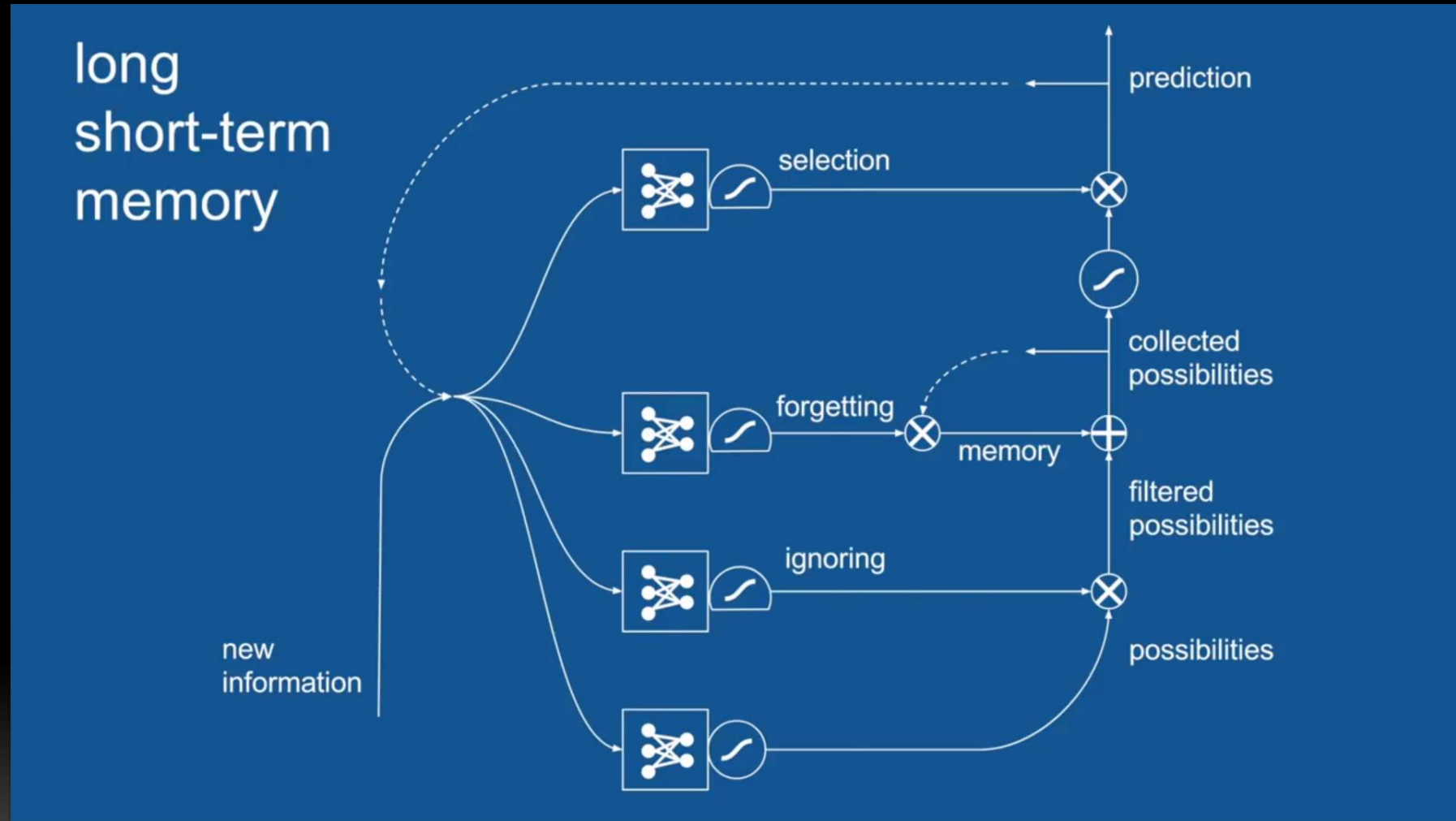
Simulation $t = 10$ sec



Recurrent Neural Nets

- Networks that can learn patterns over time
- Applications: learning sequences that evolve in time (word prediction, music recognition, robot control)
- Major Problem: Vanishing gradients during backprop
- Information lost before it can traverse the entire network

LSTM



Brandon Rohrer - Recurrent Neural Networks (RNN) and Long Short-Term Memory (LSTM)

<https://www.youtube.com/watch?v=WCUNPb-5EYI>

Hochreiter, S., & Schmidhuber, J. (1997). Long short-term memory.

Future Work

- Generating sufficient training data
- Implementation of LSTM in TensorFlow / Keras
- Optimizing hyperparameters

Questions?

References

- Li, C., Li, K., Zhang, L., Jin, S., & Zu, J. (2003). Star pattern recognition method based on neural network. Chinese Science Bulletin, 48(18), 1927-1930.
- Hong, J., & Dickerson, J. A. (2000). Neural-network-based autonomous star identification algorithm. Journal of Guidance, Control, and Dynamics, 23(4), 728-735.
- Trask, A. J. (2002). Autonomous artificial neural network star tracker for spacecraft attitude determination (Doctoral dissertation).
- Ho, K. (2012). A survey of algorithms for star identification with low-cost star trackers. Acta Astronautica, 73, 156-163.
- Spratling, B. B., & Mortari, D. (2009). A survey on star identification algorithms. Algorithms, 2(1), 93-107.
- Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). Imagenet classification with deep convolutional neural networks. In Advances in neural information processing systems (pp. 1097-1105).
- Hochreiter, S. (1998). The vanishing gradient problem during learning recurrent neural nets and problem solutions. International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 6(02), 107-116.