Machine Learning Application to Sand Dune Model Prediction Using Generative Adversarial Networks (GAN's)

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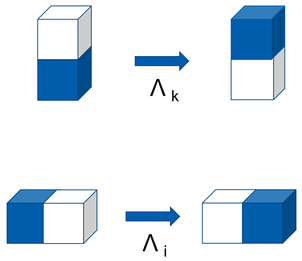
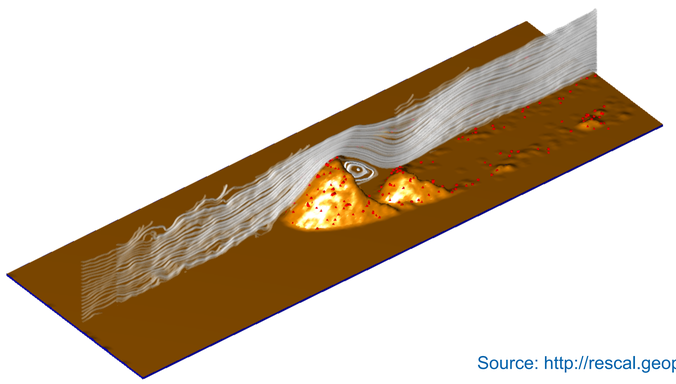
ReSCAL (real-space cellular automaton laboratory) is a simulation software used to make geomorphic predictions of sand dunes using a simple cellular automata structure. These simulations require a vast amount of both computing time and memory. Here we train a GAN to make video predictions of the sand dune model at a certain time step, F_T.

SAND DUNE PREDICTIONS ARE COMPUTATIONALLY EXPENSIVE

Each cell is treated as a "doublet", or a nearest neighbor cell, within the cell space





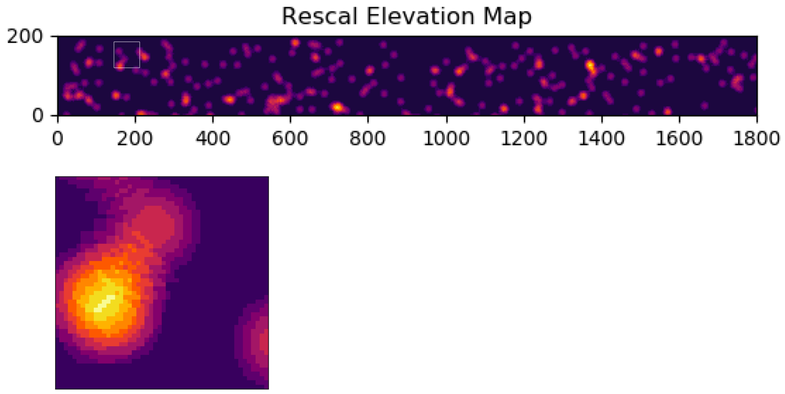
Source: http://rescal.geophysx.org/

- A 50 x 200 x 80 3D space takes 20 minutes to generate the predicted model at T_{500}[1]
- A 100 x 1800 x 200 3D space requires around 24 hours to generate the predicted model at T_{500}

[1] T_{500} is equivalent to the state of the model 13 days into the future.

SIMULATING SAND DUNE DATA

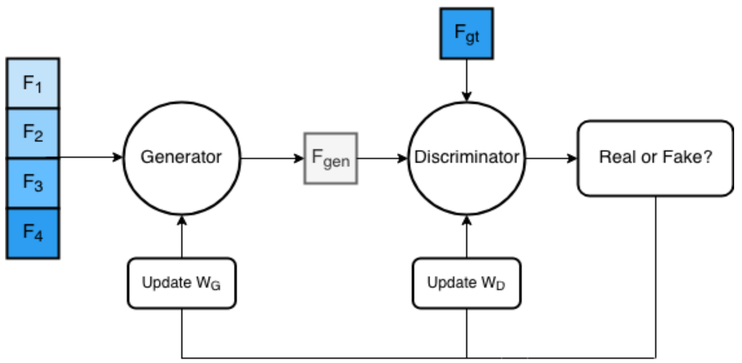
- Generate sand dune elevation values for a 3D model with dimensions 100 x 1800 x 200 until T_{500}
- Split each frame into 32 x 32 crops for training
- Train the GAN model to generate predictions of the next frame given the first four frames of the model



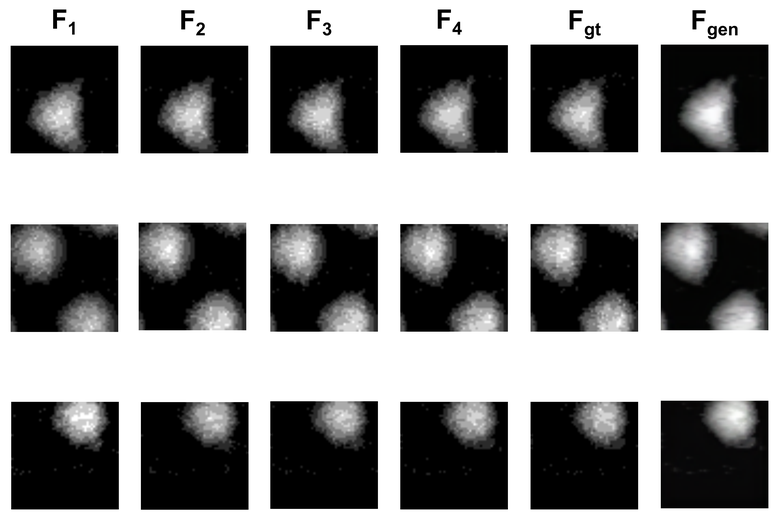
VIDEO PREDICTION USING A GAN

Generative Adversarial Networks

- Generator learns to create accurate predictions of the next frame given the past four frames
- Discriminator, or the "adversary", learns to differentiate between "real" and "fake" frames
- The generator makes more accurate predictions of the next frame, attempting to "fool" the discriminator



PREDICTED FRAME F_5



DISCUSSION/FUTURE WORK

- High level of abstraction when we treat this as a video prediction problem – we only train the model on the output at each time step
- Due to the inherent stochastic behavior of these sand dune models, the predictions will never be 100% accurate
- Compare the results for training the adversarial network and the non-adversarial network
- Train the model using images that contain a longer period of time in between each one in order to capture and predict more movement

REFERENCES

- Mathieu, Michael, Camille Couprie, and Yann LeCun. "Deep multi-scale video prediction beyond mean square error." *arXiv preprint arXiv:1511.05440* (2015).
- Rozier, Olivier, and Clément Narteau. "A real-space cellular automaton laboratory." *Earth Surface Processes and Landforms* 39.1 (2014): 98-109.
- https://github.com/dyelax/Adversarial_Video_Generation.

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Objective: Train a GAN to make accurate predictions of the sand dune model at F_5.

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