Climate Hack.AI 2022:

The story behind running an international datathon

CLIMATE HACK.AI

Jeremy Lo Ying Ping

jeremy.ping.19@ucl.ac.uk | https://jezz.me/

ARTIFICIAL INTELLIGENCE SOCIETY

Jeremy
Lo Ying Ping

- Penultimate-year MEng Computer Science student at University College London
- Development Officer and forthcoming Head of Development at the UCL Artificial Intelligence Society
  - Working on DOXA alongside Louis de Wardt
- Incoming summer 2022 Production Engineering Intern at Meta (Facebook) London
- Northerner in London

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Climate Hack.AI

A collaborative initiative between the student communities of 25 universities across the UK, US and Canada to take a lead in the fight against climate change.

In 2022, we ran an international datathon focused on satellite imagery nowcasting with the aim of helping the National Grid ESO cut UK carbon emissions.


Announcing
Climate Hack.AI
Launch: January 28th, 2022
Prize Pool: £50,000
Sponsored by
Newcross HEALTHCARE


UNIVERSITY OF MANCHESTER
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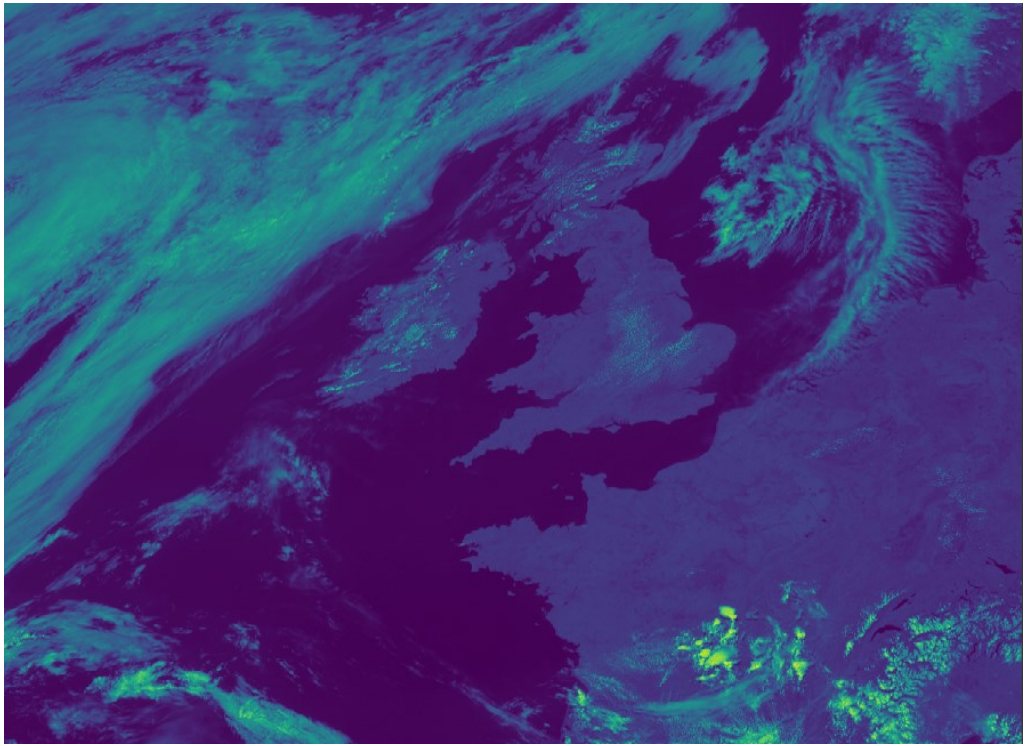
Background & Motivation

- In the UK, we have natural gas turbines on standby to make up for temporary shortfalls in solar photovoltaic power output when, for example, clouds cover a solar farm.
- If the National Grid ESO could predict near-term PV output more accurately, improved grid scheduling would allow us to reduce our dependence on natural gas (and energy bills!).
- Traditional numerical weather prediction (NWP) models are not particularly great at forecasting solar irradiance.
- One avenue is using machine learning for nowcasting – short-term forecasting (up to ~4 hours).
- Nowcasting satellite imagery (to predict the movement of clouds over solar farms) could be useful for nowcasting PV output.
- A rough estimate suggests the grid scheduling improvements could reduce UK carbon emissions by 100 kilotonnes annually!

The Dataset

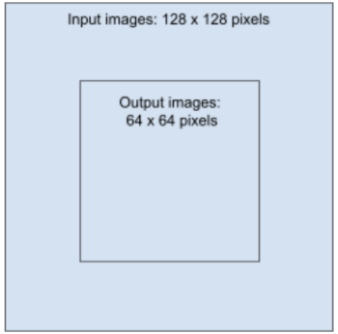
- 108 GB of ‘high resolution visible’ (HRV) EUMETSAT satellite imagery (one of twelve satellite channels) stored as a Zarr datastore compressed with bzip2
- 1,843×891 images taken five minutes apart from a geostationary position above north-western Europe between January 2020 and November 2021
- Top-of-atmosphere bidirectional irradiance values in the range [0.0, 1023.0], as well as geostationary coordinate reference system coordinates and OSGB coordinates
- Spatial resolution of 2–3 km, which decreases going northwards

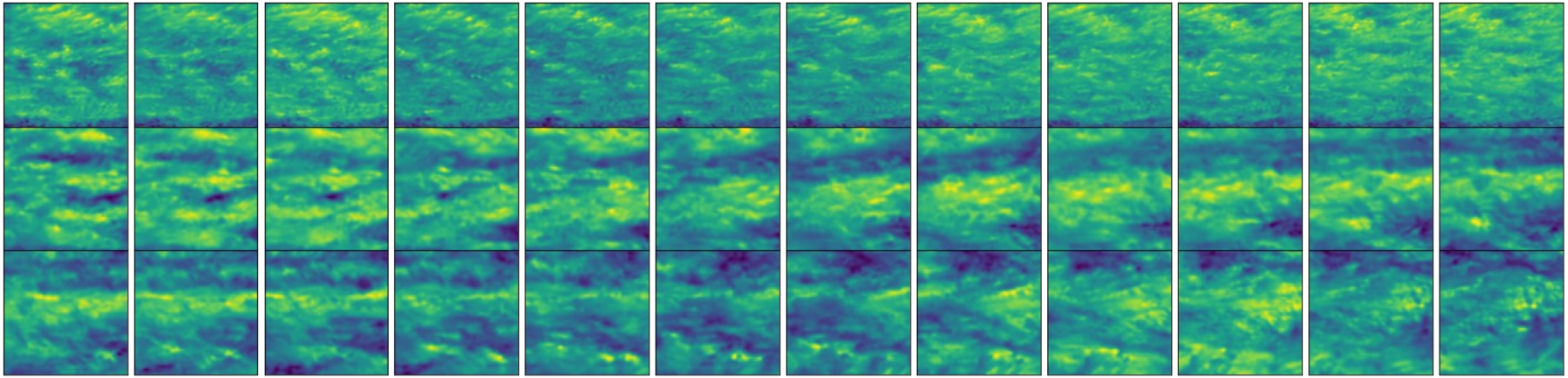


The Challenge

Input: a sequence of 12 greyscale EUMETSAT HRV satellite images taken 5 minutes apart for some 128x128 region over the UK as context imagery, as well as OSGB coordinates for the region

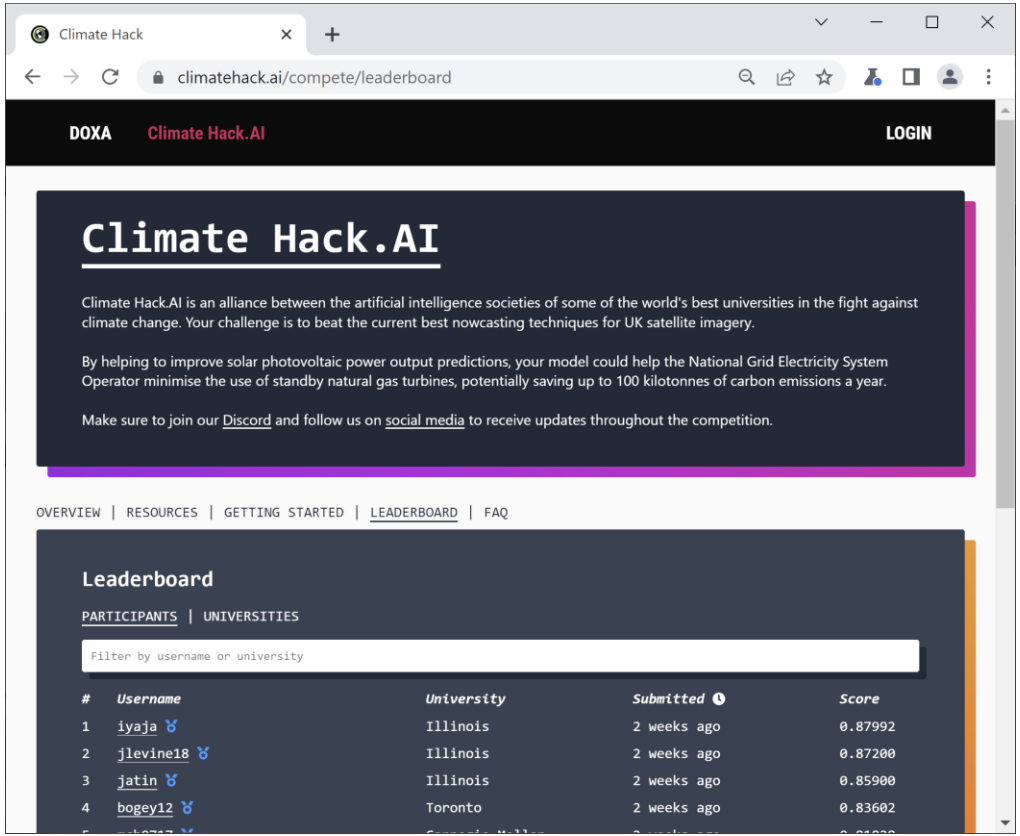
Output: a sequence of 24 images predicting how the centre 64x64 region will evolve over the next two hours



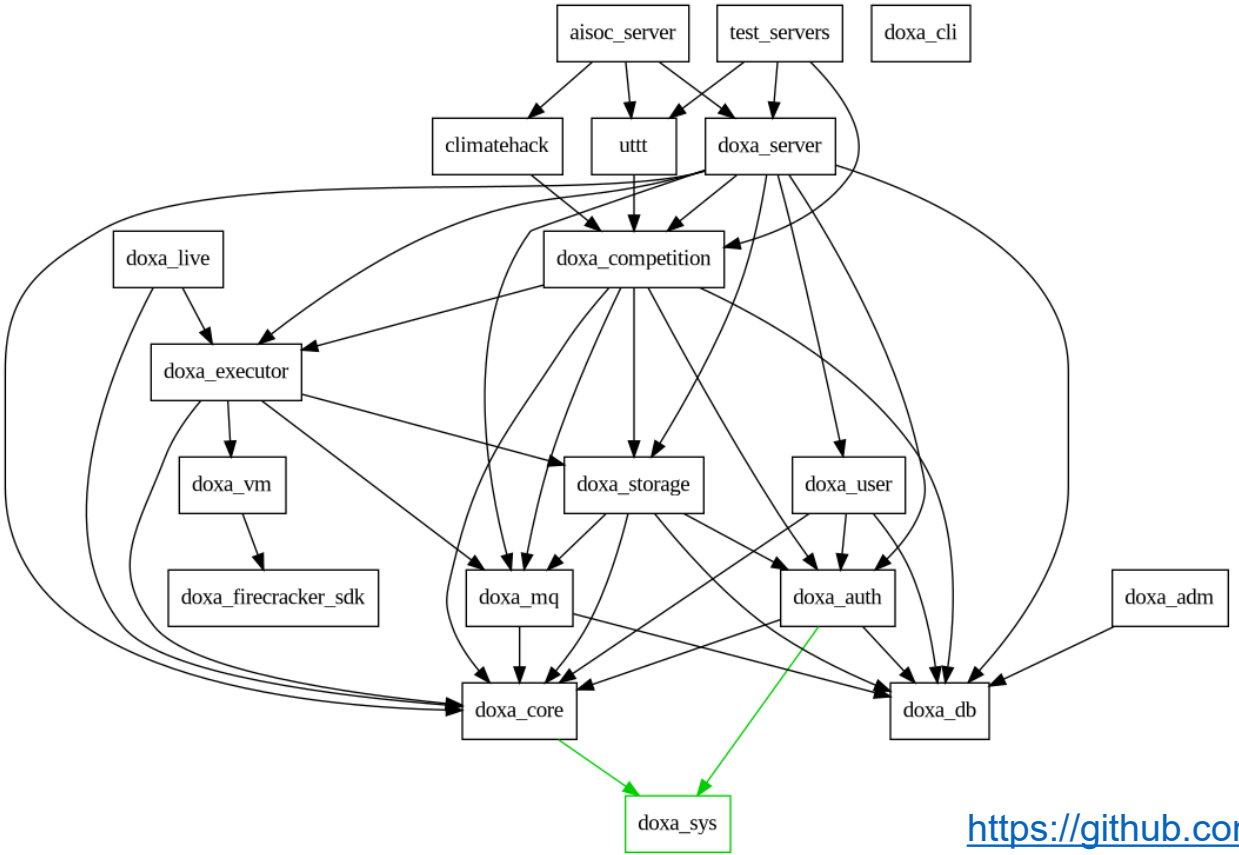


DOXA

- DOXA is a customisable AI competition platform currently maintained by the development team of UCL Artificial Intelligence Society consisting of Louis de Wardt and Jeremy Lo Ying Ping.
- The backend was developed in Rust and primarily runs participants' submissions inside Firecracker micro-VMs. (A Docker evaluation environment is also available.)
- The frontend is a React webapp.
- Submissions are uploaded using a CLI tool!
- If you would like to receive updates on the future development of DOXA, join the DOXA Community Discord server: https://discord.gg/MUvbQ3UYcf

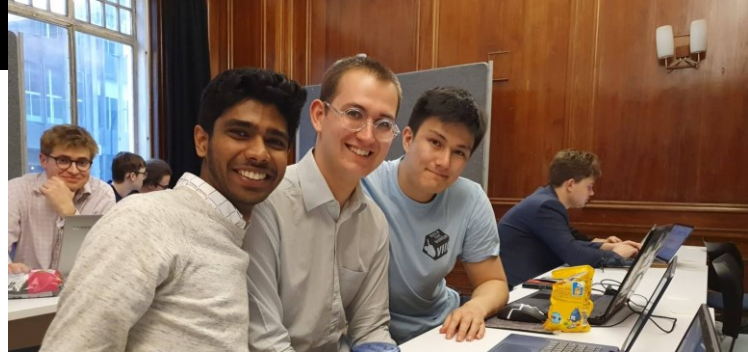


DOXA



https://github.com/louisdewar/doxa


VISA
TOMMY HILFIGER

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FIGHT CLIMATE CHANGE


MAKE A TANGIBLE IMPACT
Fight climate change


FIGHT
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CHANGE


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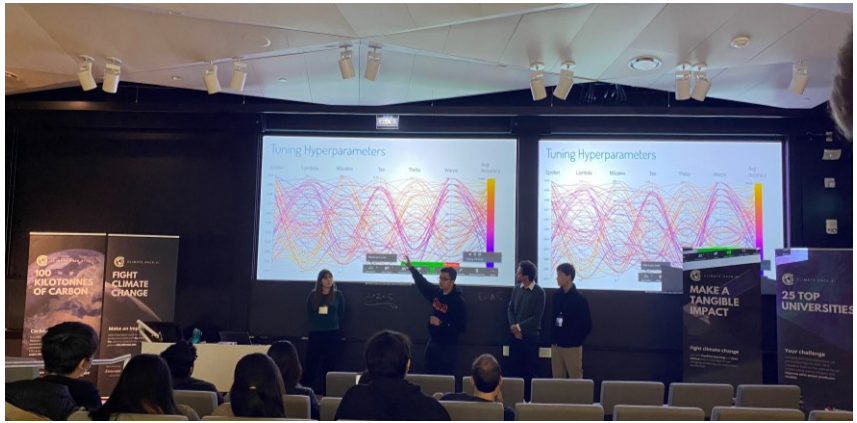
The Final Presentations

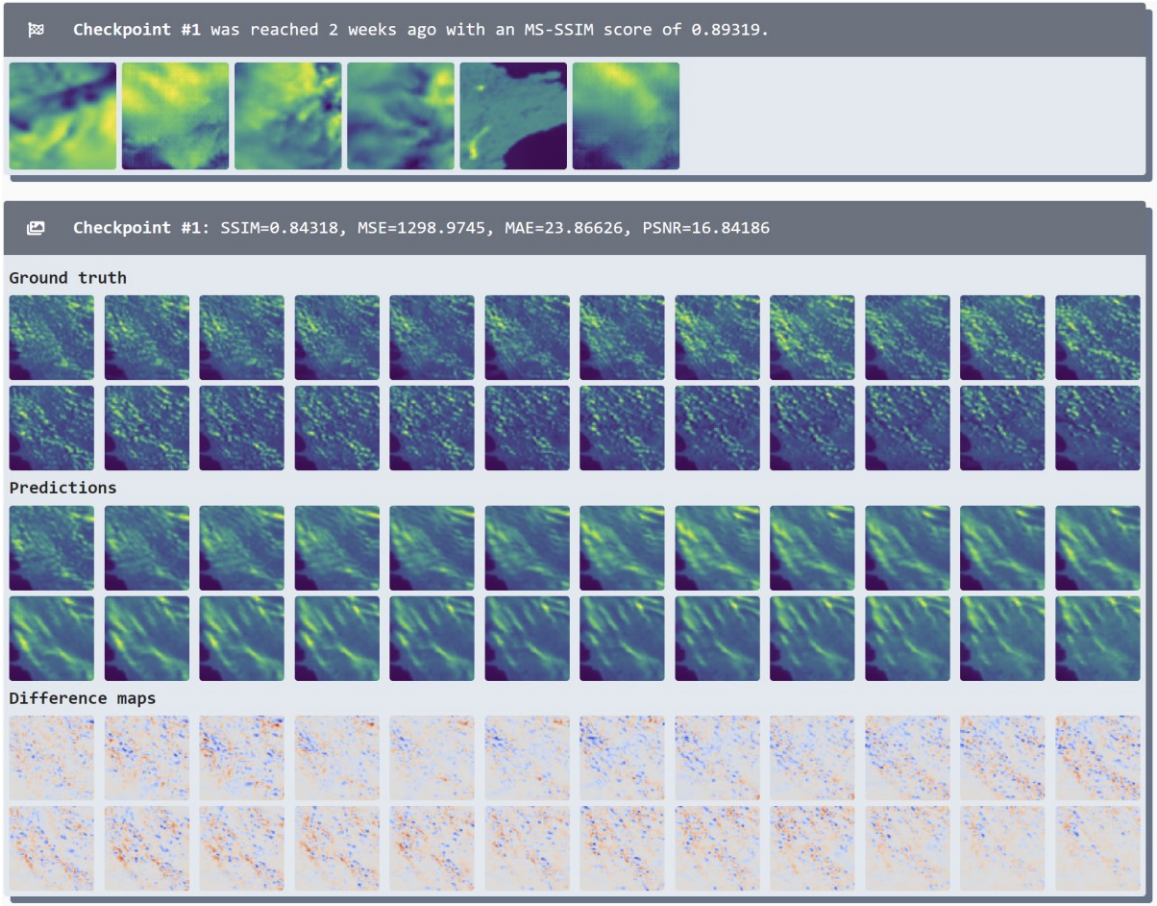


The Winning Universities

1. The University of Illinois at Urbana-Champaign
2. The University of Toronto
3. Carnegie Mellon University

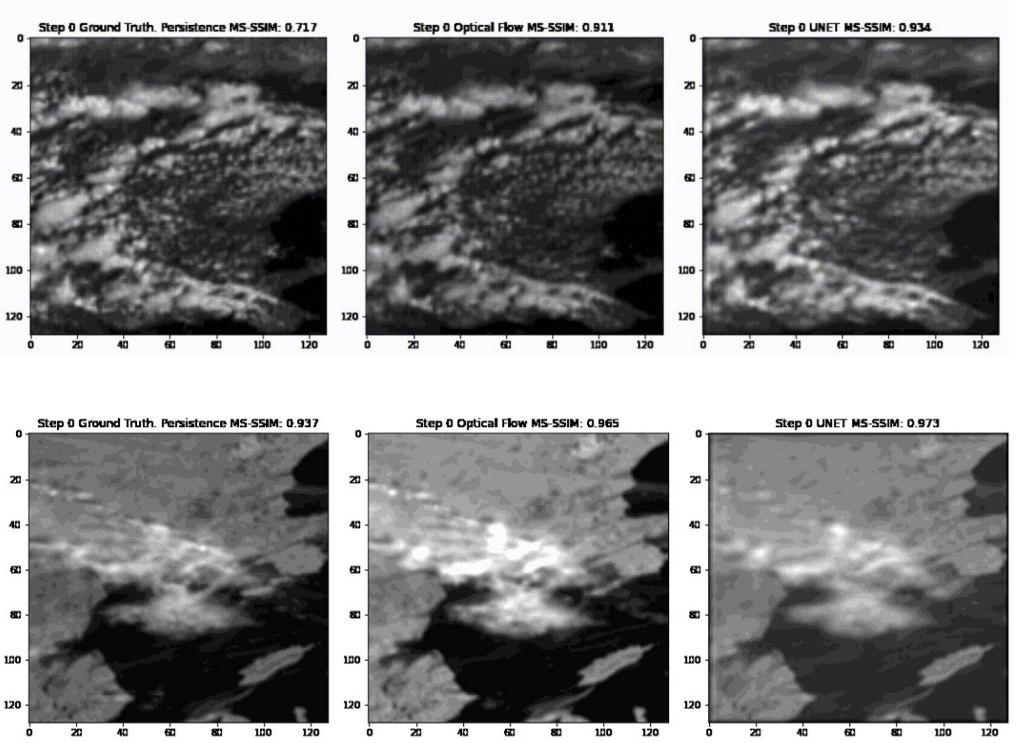
The Best Submission

- This was the winning entry submitted by Jatin Mathur, Ajay Arasanipalai and Jacob Levine of the University of Illinois at Urbana-Champaign ACM Special Interest Group for Artificial Intelligence & Data Analytics.
- Final presentation slides: https://docs.google.com/presentation/d/1P_cv3R7gTRXG41wFPXT2lZe9E1GnKqtaJVqe-vsAvL0/edit#slide=id.g35f391192_00
- GitHub repository: https://github.com/jmather625/climatehack/



The Best Submission

- The Dynamic UNet class in the fastai library was used to generate a complete UNet model with automatic self-attention from an XSE ResNeXt50 Deeper encoder.
- They used the Mish activation function, as well as the Ranger deep learning optimiser.
- Their novel contribution towards the state of the art was to apply the discrete cosine transform (DCT) – used in JPEG and the H.264 video codec – and its inverse as a convolution to transform $(128, 128)$ images into $(64, 16, 16)$.
  - For more information, see this paper: Gueguen, L., Sergeev, A., Kadlec, B., Liu, R. and Yosinski, J., 2018. Faster neural networks straight from jpeg. Advances in Neural Information Processing Systems, 31.
- They also added a denoising filter and augmented their input features with the OSGB coordinates and optical flow.



https://github.com/jmather625/climatehack/

Other Participants' Approaches

- Convolutional neural networks (CNNs) – both Conv2d and Conv3d
- Convolutional LSTM (ConvLSTM) and convolutional GRU (ConvGRU) networks
  - Shi, X., Chen, Z., Wang, H., Yeung, D.Y., Wong, W.K. and Woo, W.C., 2015. Convolutional LSTM network: A machine learning approach for precipitation nowcasting. Advances in neural information processing systems, 28.
- Trajectory GRU (TrajGRU)
  - Shi, X., Gao, Z., Lausen, L., Wang, H., Yeung, D.Y., Wong, W.K. and Woo, W.C., 2017. Deep learning for precipitation nowcasting: A benchmark and a new model. *Advances in neural information processing systems*, *30*.
- PredRNN
  - Wang, Y., Wu, H., Zhang, J., Gao, Z., Wang, J., Yu, P.S. and Long, M., 2021. PredRNN: A recurrent neural network for spatiotemporal predictive learning. *arXiv preprint arXiv:2103.09504*.
- Perceiver & Perceiver IO
  - Jaegle, A., Gimeno, F., Brock, A., Vinyals, O., Zisserman, A. and Carreira, J., 2021, July. Perceiver: General perception with iterative attention. In *International Conference on Machine Learning* (pp. 4651-4664). PMLR.
  - Jaegle, A., Borgeaud, S., Alayrac, J.B., Doersch, C., Ionescu, C., Ding, D., Koppula, S., Zoran, D., Brock, A., Shelhamer, E. and Hénaff, O., 2021. Perceiver io: A general architecture for structured inputs & outputs. *arXiv preprint arXiv:2107.14795*.
- Vision Transformers (ViT)
  - Dosovitskiy, A., Beyer, L., Kolesnikov, A., Weissenborn, D., Zhai, X., Unterthiner, T., Dehghani, M., Minderer, M., Heigold, G., Gelly, S. and Uszkoreit, J., 2020. An image is worth 16x16 words: Transformers for image recognition at scale. *arXiv preprint arXiv:2010.11929*.
- Class-Attention in Image Transformers (CaiT)
  - Touvron, H., Cord, M., Sablayrolles, A., Synnaeve, G. and Jégou, H., 2021. Going deeper with image transformers. In *Proceedings of the IEEE/CVF International Conference on Computer Vision* (pp. 32-42).

Further Resources

- Ravuri, S., Lenc, K., Willson, M., Kangin, D., Lam, R., Mirowski, P., Fitzsimons, M., Athanassiadou, M., Kashem, S., Madge, S. and Prudden, R., 2021. Skilful precipitation nowcasting using deep generative models of radar. Nature, 597(7878), pp.672-677.
- Sønderby, C.K., Espeholt, L., Heek, J., Dehghani, M., Oliver, A., Salimans, T., Agrawal, S., Hickey, J. and Kalchbrenner, N., 2020. Metnet: A neural weather model for precipitation forecasting. arXiv preprint arXiv:2003.12140.
- Espeholt, L., Agrawal, S., Sønderby, C., Kumar, M., Heek, J., Bromberg, C., Gazen, C., Hickey, J., Bell, A. and Kalchbrenner, N., 2021. Skillful Twelve Hour Precipitation Forecasts using Large Context Neural Networks. arXiv preprint arXiv:2111.07470.
- Open Climate Fix's report 'Solar PV Nowcasting Using Deep Learning' available at the following URL: https://docs.google.com/document/d/1vVmkGRxDkAKbFwfKbEWnN0-dToVEXQ6rPyUNT0C535w/edit
- For more, see the Climate Hack.AI resources page: https://climatehack.ai/compete/resources


Martin Weigold
FIGHT
CLIMAT
CHANG
ILLINOIS

Thank you for listening :)

I would be more than happy to take any questions.

I hope to see as many of you as possible competing in Climate Hack.AI 2023 in the next academic year!

The slides for this talk are available at the following link:

https://jezz.me/talks/2022-04-12-SKAO-JBCA-ML-club-slides.pdf

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DOXA