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#NewPerspectives

10 – 11
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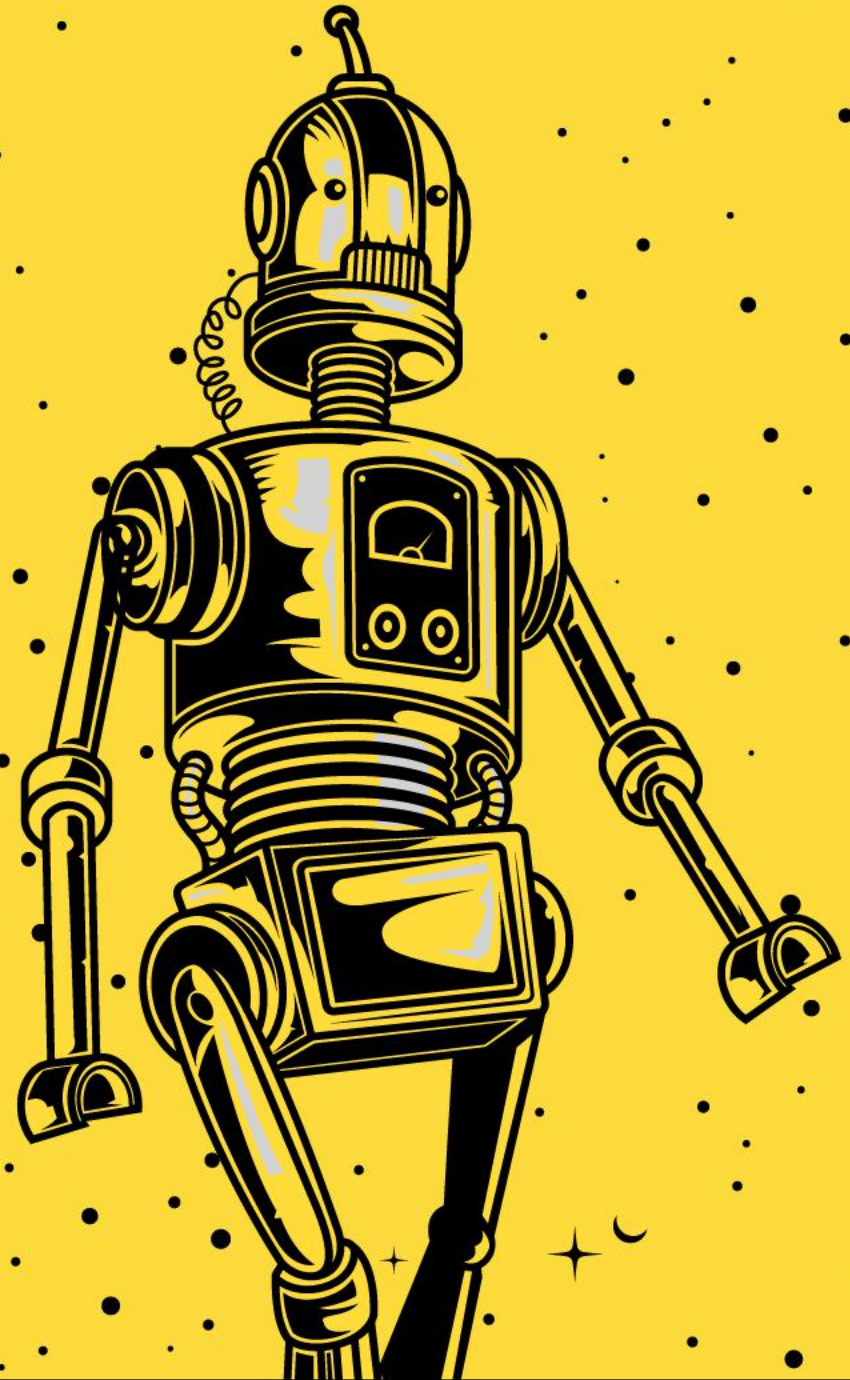

Enhancing the performance of weather nowcasting by use of machine learning techniques applied on weather data

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Weamyl project

- Collaboration between:
  - Babeș-Bolyai University (BBU)
  - Romanian National Meteorological Administration (ANM)
  - Norwegian Meteorological Institute (MET)
- Major goal: provide an efficient, seamless nowcasting platform which will be integrated with national warning systems
- The platform will:
  - provide precise nowcasting using Machine Learning methods
  - managing large amounts of meteorological data using Big Data approaches

Weather nowcasting

- Nowcasting: weather forecasts for the next **0 to 6 hours**
- According to World Meteorological Organization (WMO), severe weather is responsible for damage and loss of life
- Good nowcasting ⇒ issuing of relevant early warnings

- Predicting short-term weather is a *difficult* task for meteorologists
- Complexity: huge amount of data which has to be processed and analyzed

Current systems in use

- Some nowcasting systems used today based on radar data extrapolation:
  - TITAN by Dixon and Wiener
    - useful for single cell tracking
  - FAST by Jung and Lee
    - uses fuzzy logic
  - AROME
    - small scale numerical prediction model with AROME-NWC for predicting in the range of 0-6 hours
- Limitations:
  - Specific for a geographic region - not adaptable
  - Problems with storm segments with irregular shapes or with variable speed

Data used and predicted

- Radar Data:
  - Data provided on a wide area by ground based stations
  - Provides data such as: *Reflectivity* (paticle size) and *Velocity* (particle velocity) among others
- Satellite data
  - Satellite imagery provides information on atmospheric and ground conditions including areas not covered by weather radars
  - Broad range of data collected: *surface reflectance*, *moisture content*, *ozone concentration* etc.
- Also considering using other data:
  - temperature
  - geographical features
  - other

Not all data is the same

- Radar data gathered can be different in different regions
  - different types of radar can gather different types of data
    - ANM Romania uses single polarization radars
    - MET Norway uses dual polarization radars
  - different data preparation (data preprocessing, data cleaning, data correction etc.)

⇒ difficulty in making one model that fits all cases

- We need to crate *separate* prediction models for *separate* regions

Machine learning techniques

- Main machine learning method used: *Deep Neural Networks*
- Currently our prediction model is based on:
  Convolutional Deep Neural Networks
- Some other methods used during our research:
  - self organizing maps
  - autoencoders
  - relational association rules mining

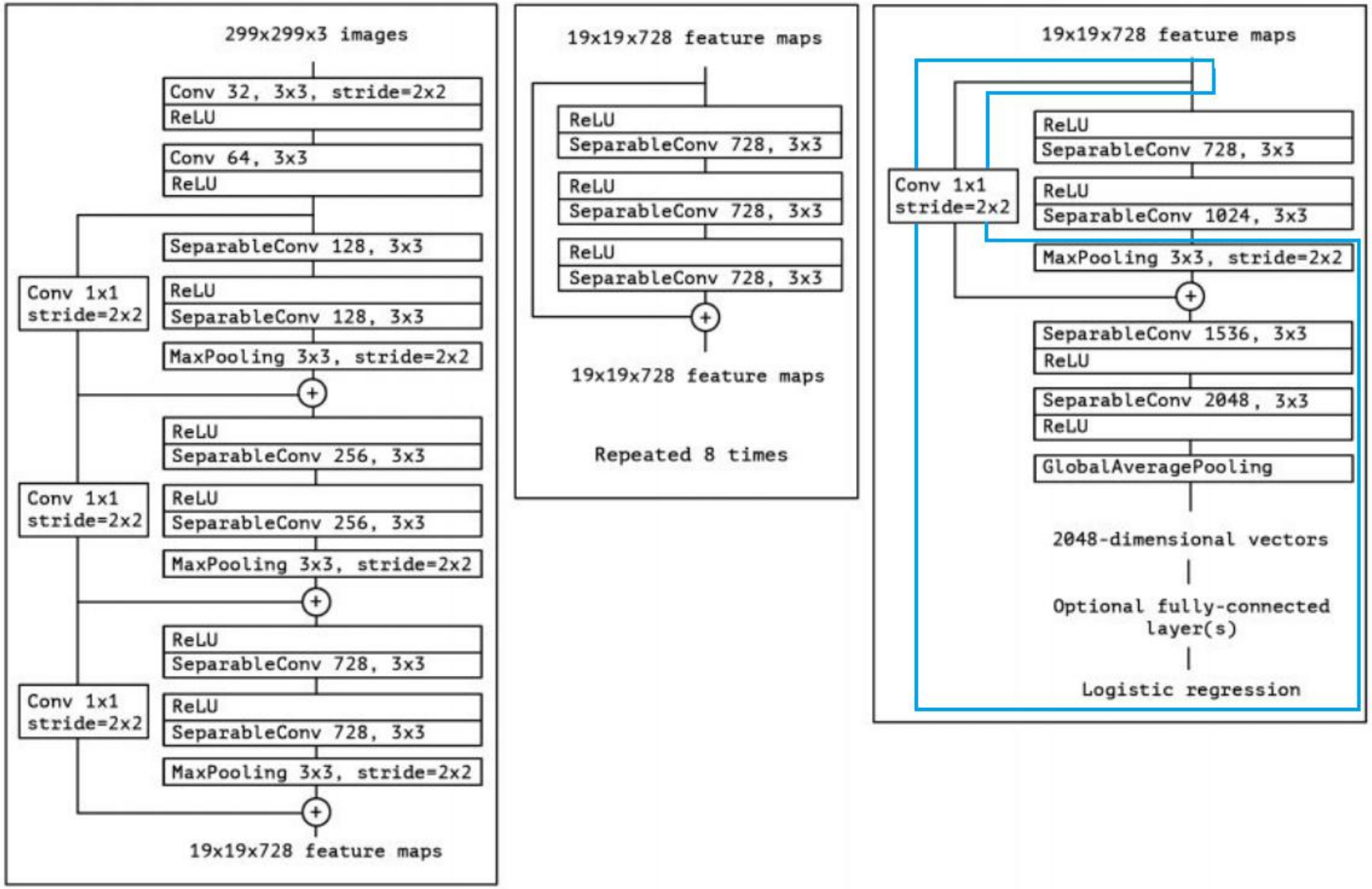
NowcastX model ideea

- From the data at one time step predict the data at the next time step
- Adapt data to be view as images:
  - sattelite data is already gathered in from of images
  - radar data can be structured into a data model that can be viewed as an image where each channel is a radar product
- Take advantage of powerful Computer Vision neural network models:

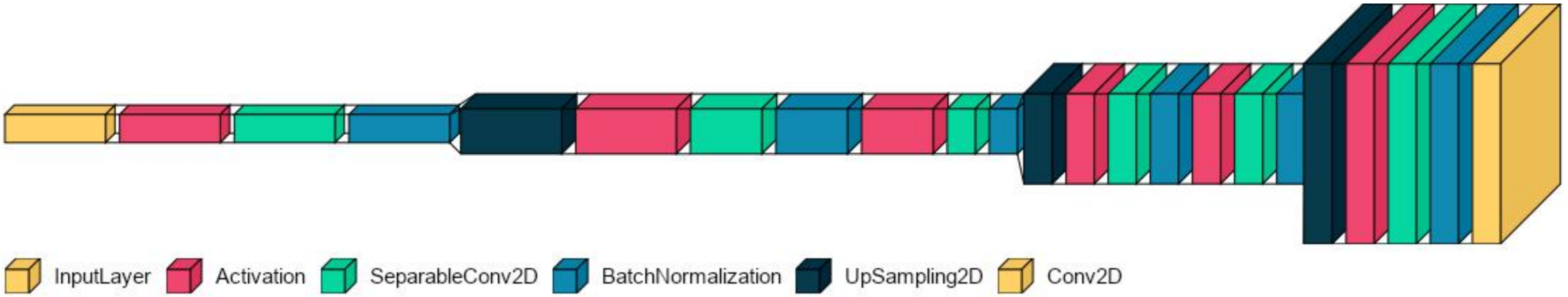
  The Xception Model

Xception model

Figure: The original Xception model, with a mark (the blue lines) on the part that we consider for replacement



NowcastX model decoder

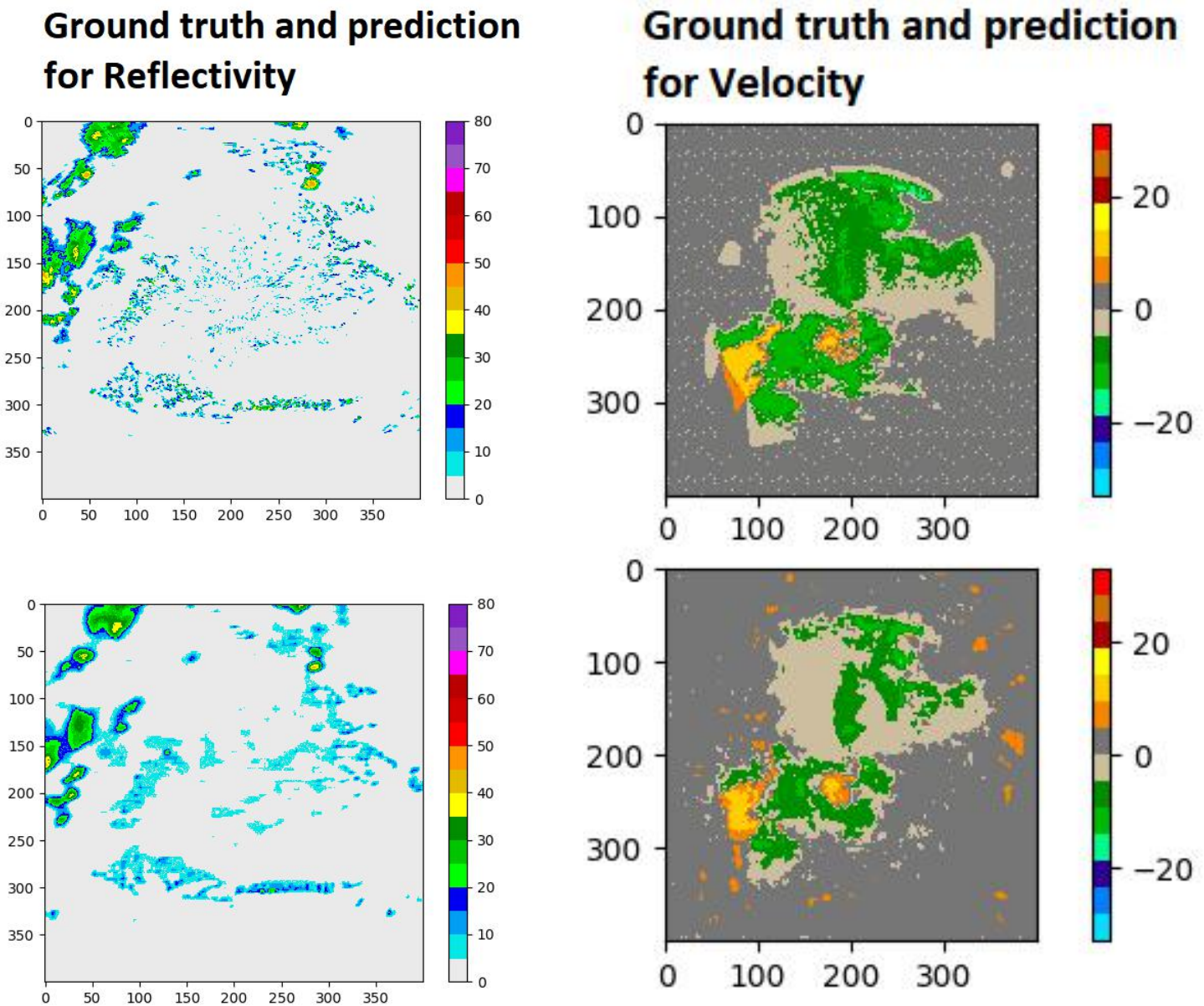


- Figure: The decoder that we used in our model replacing the end part of the Xception model.

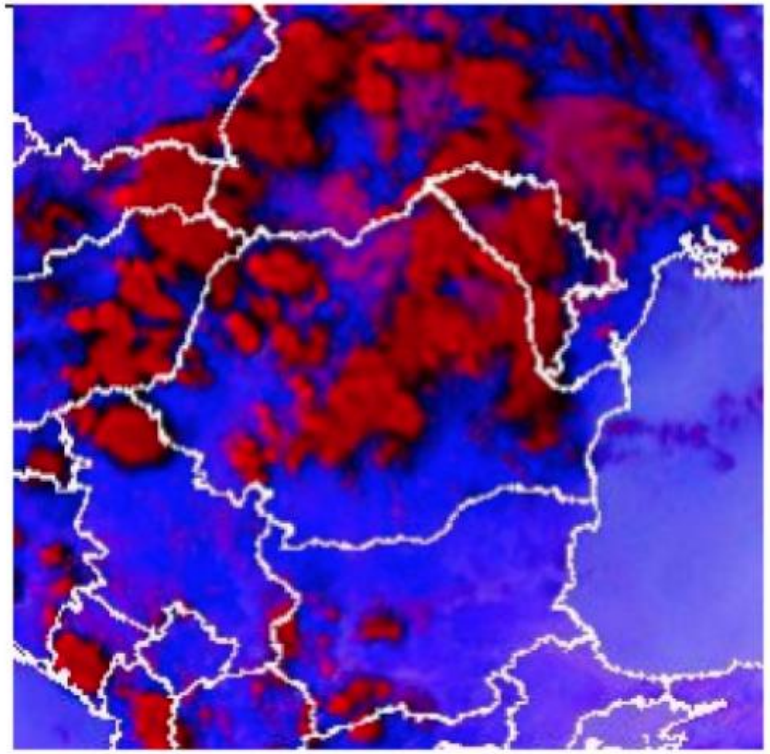
NowcastX results - radar data

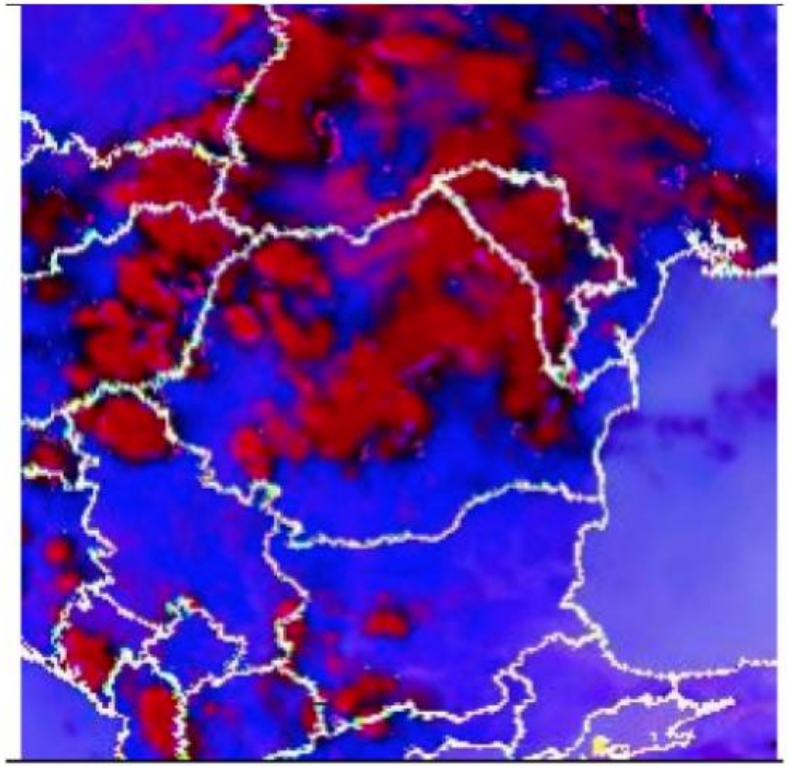
Figures: examples of predictions and their comparisons to ground truth for two radar products

radar data prediction video:
https://weamyl.met.no/models/



NowcastX results - satellite data





Figures: grund truth (left) and prediction (right) for a satellite image.

NowcastX model variations

- Research in progress
- The model needs to be adapted and perfected

- Techniques we use:
  - adapting the training loss:
    e.g. give more weight to non-zero values or to higher values
  - train and predict separately for each product

- Too much fine-tuning may lead to overfitting for one dataset or for one testing measure

Evaluation measures

- Regression measures: Mean Squared Error (MSE) and Root Mean Squared Error (RMSE)
  - $MSE = \frac{1}{n}\sum_{i=1}^{n}(real_i - predicted_i)^2$
  - $RMSE = \sqrt{MSE}$
  - Non-Zero RMSE
- Classification measures: Critical Success Index (CSI)
  - $CSI = \frac{True\ Pozitive}{True\ Pozitives + False\ Pozitives + False\ Negatives}$
- Expert feedback

Difficulty comparing to related work

- In order to asses the model comparison to state of the art is needed
- Difficulties in comparisons with other exoperiments:
  - Different experiment design (which products used, and how, regression vs classification etc.)
  - Different nowcasting predictions (e.g. predicting precipitations instead of reflectivity)
  - Different dataset over different regions (using different kinds of radars etc.)
- Often the dataset or model are not accessible/open source ⇒ direct comparisons are impossible

Conclusions and Future Work

- The WeaMyL project: a collaboration project between UBB, MET and ANM to develop a machine learning-based nowcasting platform to be integrated in national warning systems
- The NowcastX model: our current weather nowcasting model based on Convolutional Deep Neural Networks

- Future work:
  - Perfect the NowcastX model
  - Predict further into the future
  - Create a model based on Convolutional LongShort Term Memory Networks (ConvLSTM)

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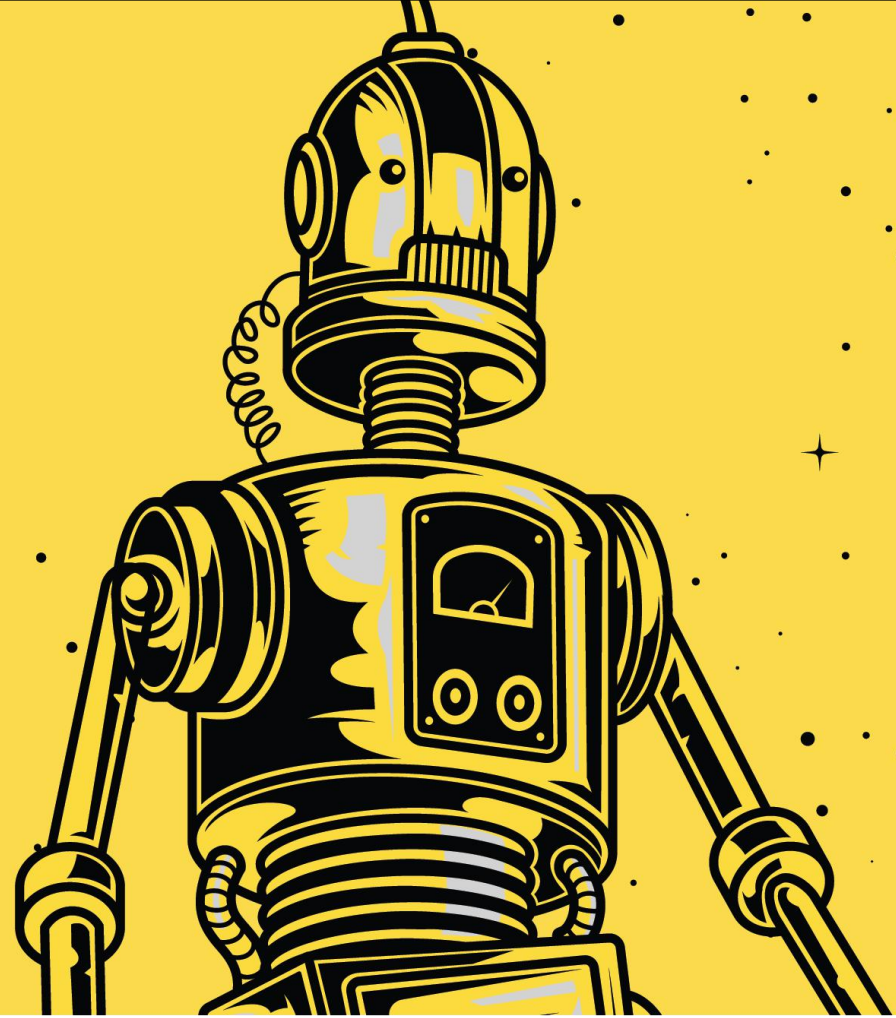

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