

Standards, formats and interoperability protocols for Deep Learning models in OpenDR

Data/AI Standards and Data Governance - BDVA/DAIRO Workshop

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Project: **OpenDR (opendr.eu)**

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OpenDR (opendr.eu)

- OpenDR aims to develop a **modular, open and non-proprietary toolkit for core robotics** functionalities by harnessing **DL** to provide **advanced perception and cognition capabilities**
 - Easy-to-use and accessible
 - AI on the edge through lightweight DL
 - High-resolution real-time inference
 - Active Perception-enabled
- Meeting the general requirements of robotics applications in different applications areas

Deep Learning (DL)

- State-of-the-art Machine Learning models
- Variety of architectures
 - **Convolutional Neural Networks**
 - **Recurrent Neural Networks**
 - **Transformer-based Architectures**
 - ...
- Applications in **computer vision, robotics, speech recognition, natural language processing, bioinformatics**, and many others!

DL Frameworks

- DL is
 - computationally intensive
 - hard to code from scratch
 - usually requires **dedicated hardware** (e.g., GPUs)
- Several **DL frameworks** have been developed!



Data Formats and Processing Pipelines

- DL involves both data and operations on them!
 - **Input data**
 - **Models**
 - **Outputs**
 - **Normalization**
 - **Operators**
 - **Streaming pipelines, ... (many other things)**
- **Even straightforward things are not always simple!**

Data Formats and Processing Pipelines

DL model 1 input



What DL model 2 saw



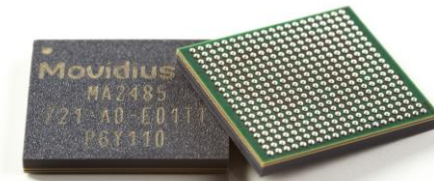
Pixabay License (<https://pixabay.com/photos/sunflowers-field-sunset-sun-6007847>)

Data Formats and Processing Pipelines

- **How can we represent an image?**
 - Channels first or last?
 - BGR or RGB?
 - 0...255 *uint8* or 0...1 *float*?
 - Normalization pipeline (e.g., standardization)
 - Even simple inputs can be handled in many different ways!
- **Can we exchange a model?**
 - In early days of DL this required significant effort if different frameworks were used!
- Things are getting better (stay tuned!)
- **DL landscape is still fragmented!**

Deployment and Hardware Integration

- Deployment and hardware integration is even more challenging
- Many different platforms!
- Many different optimizers!



Standardization Attempts

- Open Neural Network Exchange (ONNX)
 - **ONNX is an open format built to represent machine learning models**
 - **ONNX defines a common set of operators and a common file format to enable AI developers to use models with a variety of frameworks, tools, runtimes, and compilers.**

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skymizer

TwinCAT® 3

Interoperability and Data Formats in OpenDR

- **Extensive support for ONNX models**
 - Model format is among the most critical aspects of interoperability in DL!
 - ONNX is designated to be a first-class citizen for OpenDR
 - Solves most DL-related issues
 - **Standard model format (can be read, optimized and deployed to a great number of devices)**
 - Effort to optimize and export models in ONNX format
 - Legacy models (e.g., based on TF and PyTorch) are still supported

Interoperability and Data Formats in OpenDR

- **Avoided re-defining formats when not needed**
 - Attempts to standardize datasets were not very successful and usable (e.g., Fuel, ...)
 - We leverage existing datasets format provided by well-known datasets
- **Input/Output format consistency**
 - No established standard exists
 - OpenDR provides a wide variety of different models and tools developed by many different partners
 - Use of simple wrapper classes to ensure that all models receive the same inputs and provide the same output (internal consistency)
 - Use of standard practices and conventions (external usability)

Thank you!
Questions?