| **COURSE: OPEN MACHINE LEARNING FOR EARTH OBSERVATION IN RWANDA** | | | | |
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| **MODULE** | **KEY CONTENT** | **LEARNING OBJECTIVES** | **RESOURCES** | **METHODS/ DIDACTICAL AIDS** |
| **Module 0:**  Introduction to the course  Online  (6 contact hours live session + self-directed) | * Onboarding of course participants * Tech Check | * A common understanding about the structure, format, objectives and contents of the training course has been established. * Participants are familiarized with the online environment and virtual learning management system * A good learning atmosphere for the online and presence-based training parts has been established. * Participants and trainers have been introduced to each other. |  | Login, registration and first steps/ tasks on the learning management system Moodle |
| **Module 1:**  Introduction to GIS  **21 Feb 2023**  Online  (3 contact hours live session + self-directed) | * Session 1: Definition and Key Concepts * Session 2: Spatial Data * Session3: Mapping References * Session4: Spatial Data analysis * Session5: Application and Documentation | * Define Geographical information systems and related terminologies * Analyse the potential uses of GIS * Discuss how to project spatial data in GIS * Create a map with given data (depending on if they will be discussed in the exercises) * Basics of cartography * Create data in GIS * Run a spatial analysis in GIS |  | Task/content type:  - Live session  - Reading material  - Video  - Links to resources  - Task |
| **Module 2: Introduction to RS**  **27 Feb 2023**  Online  (3 contact hours live session + self-directed) | * Session 0: Introduction to Remote Sensing * Session 1: Fundamentals of Remote Sensing * Session 2: Electromagnetic Radiation * Session 3: Energy Interactions * Session 4: Information extraction * Session 5: Application and Documentation | * Reflect on Remote Sensing (RS) principles * Define electromagnetic waves and their characteristics * Describe the role of the Earth’s atmosphere for remote sensing * Satellites data * Conduct simple analysis using a range of different types of optical Earth observation (EO) data |  | Task/content type:  - Live session  - Reading material  - Video  - Links to resources  - Task |
| **Module 3:**  GIS data collection methods  **13 March 2023**  Online  (3 contact hours live session + self-directed)  +  **15 May 2023, Kigali region, Field trip**  In-person  (8 contact hours) | * Session 1: Fundamental concepts of spatial data * Session 2: Primary GIS data collection methods * Session 3: Secondary GIS data collection methods * Session 4: Obtaining data from external sources (data conversion and transfer) * Session 5: Fieldwork and application exercise on GIS data collection | * Understand the basic concepts of GIS data * Understand how GIS data is collected * Consider the possibilities of working with various GIS data (raster, vector) * Describe the potential use of spatial/EO data * Deal with spatial data interoperability * Consider examples of collecting spatial/EO data, e.g., through an app * Conduct simple spatial data collection on the field | Field data collection – Sinergise:  <https://www.youtube.com/watch?v=w0HiVBmP-QY&t=11s> | • Live session  • Reading material  • Video  • Links to resources  • Task  • Fieldwork |
| **Module 4:**  Intro to ML and Python  **20 March 2023**  Online  (3 contact hours live session + self-directed) | * Session 1: Introduction to Machine Learning * Session 2: ML training data and web mapping * Session 3: Machine learning algorithms for image classification * Session 4: Python programming and Jupyter Notebook * Session 5: Fieldwork: image classification | * Understand the goals of AI * Define learning, machine learning, and understand the goal of learning * Understand the need for machine learning, and the capabilities of machine learning * Understand the difference between the learning algorithm, and the learned classifier * Describe the process of training data generation * Explain the process of devising an ML solution * Understand the basics of artificial neural networks * Differentiate between the different types of learning * Understand the potential of ML learning in EO * Understand how ML is used in image classification * Understand the different approaches to feature extraction from EO data * Understand the basics of the programming language Python and the application Jupyter Notebook * Install Jupyter Notebook and practice basic coding * Understand the basics of Sentinel Hub as an EO Processing Platform * Simple spatial data collection on the field and analysis |  | Task/content type:  - Live session  - Reading material  - Video  - Links to resources  - Task  - Fieldwork |
| **Module 5:**  Data Curation and Visualization of EO Data For Machine Learning  **15th & 16th April 2023, Digital Transformation Centre, Kigali**  In-person  (16 contact hours) | * Data curation for ML (refresher) * Data curation with image datasets * Data curation with EO data * Visualization of EO data | Participants will be able to:   * investigate the concept and meaning of data curation (for ML) * explain the data cleaning process for structured data * Collect structured raw data, or acquire data from source, and cater it to their task * Transform numerical and categorical data * Explain the different image pre-processing, augmentation, and EDA approaches * Apply image pre-processing, augmentation, and EDA approaches * Explain the different types of approaches to correct EO images * Visualize image data, and summarize an image dataset * fetch data from different EO Engines * perform cloud masking and removal * Describe what information we can gather from EO display * Apply pre-processing steps for optical imagery * visualize EO data bands * filter images, and reduce image collections | **Module Reader:**  *Introduction to data cleaning and processing*  **Videos / Articles etc.**   What is data collection? - https://www.youtube.com/watch?v=Lb6Gi6IR-Kc   What is data quality and why is important? - https://www.youtube.com/watch?v=GWiiZWb69Sw   Python machine learning – online class (19:01): data cleaning in Jupyter notebook:   https://www.youtube.com/watch?v=T18rp49owgM   Handling Missing Data Easily Explained| Machine Learning (23:21): https://www.youtube.com/watch?v=P\_iMSYQnqac   Handling Missing Values in Machine Learning | Imputation | Dropping (21:58): https://www.youtube.com/watch?v=GzZmfe030PU | Task/content type:   * Reading material * Linked resources * Lectures * Demos * Code-alongs * Exercises * Quiz |
| **Module 6:**  Predictive modelling using local remote sensing data  **12th to 13th May 2023, Digital Transformation Centre, Kigali**  In-person  (16 contact hours) | * Introduction to use cases in predictive modelling using EO/RS data * Machine Learning methods & considerations **specific to EO data** * Transfer learning (summary of popular open-source models available for fine tuning) | Participants will be able to:   * Understand common use cases for predictive modelling using EO data analysis (including semantic segmentation of land use and crop type mapping, and crop yield prediction). * Identify the main challenges and opportunities associated with each common use case. * Identify the data requirements and sources for each common use case. * Be aware of additional use cases * Understand popular model architectures (algorithms) for ML using EO data and the various pros and cons of each (incl. CNNs, Random Forests, SVMs) * Understand variations on standard ML methods for training predictive models using EO data * Identify the key considerations and challenges associated with using EO data for predictive modelling (data preprocessing, feature selection, and model selection) * Understand considerations for assessing the performance of predictive models using EO data * Identify popular open-source models available for transfer learning in EO data analysis (including: VGG-16, ResNet, MobileNetV2 and Inception-v3) * Understand the main techniques and considerations associated with fine-tuning pre-trained models for specific EO data analysis tasks. | **Module Reader:**  *Predictive modelling using local remote sensing data*  **Videos / Articles etc.**  • Video/Workshop: NASA ML4EO Workshop 2020 - YouTube  • Video/Tutorial: FAO Webinar Series: Earth observation data for agricultural statistics  • Video: Hanna Meyer - Machine learning for earth observation - YouTube  • Webpage <https://eo-college.org>  • YouTube Channel https://www.youtube.com/@EOCollege  • Resource: Digital Earth Africa https://maps.digitalearth.africa  • Resource: ESA Copernicus Open Access Hub  • Resource: Awesome Spectral Indices https://awesome-ee-spectral-indices.readthedocs.io/en/latest/index.html | Task/content type:   * Reading material * Linked resources * Lectures * Demos * Code-alongs * Exercises * Quiz |
| **Module 7:**  ML workflow best practice  **14 May 2023, Digital Transformation Centre, Kigali**  In-person  (8 contact hours) | * Efficient hyperparameter tuning for EO data modelling * Experiment Tracking * Continuous Integration / Continuous Deployment (CI/CD) with ML | Participants will be able to:   * Understand the importance of optimizing resource usage in computer vision tasks * Explain common approaches to efficient hyperparameter tuning * Understand the importance of taking a systematized approach to ML * Explain the core elements of experiment tracking * Describe common approaches to experiment tracking including specific toolkits * Demonstrate capacity to train and tune the hyperparameters of a model using an experiment tracking workflow * Understand the benefits of CI/CD for ML workflows * Explain specific aspects of CI and CD for ML workflows | **Module Reader:**  *ML workflow best practice*  **Videos / Articles etc.**   * Article: Comparing Modern Scalable Hyperparameter Tuning Methods | by Ayush Chaurasia | Towards Data Science * Paper: Practical Bayesian Optimization Of Machine Learning Algorithms * Article - [10 tips for machine learning experiment tracking and reproducibility: Do it yourself approach without additional tooling](https://developer.ibm.com/blogs/10-diy-tips-for-machine-learning-experiment-tracking-and-reproducibility/) – IBM Developer * Artcile: [Machine Learning Experiment Tracking with WandB](https://towardsdatascience.com/machine-learning-experiment-tracking-93b796e501b0) * Article: [WandB — The Best MLOps Platform](https://medium.com/mlearning-ai/wandb-the-best-mlops-platform-bf3aa31b162e) * MOOC: [Effective MLOps: Model Development with WandB](https://www.wandb.courses/courses/effective-mlops-model-development?utm_source=youtube&utm_medium=video&utm_campaign=course-video-ad) * Organization: [MLOPS.org](https://ml-ops.org/) | Task/content type:   * Reading material * Linked resources * Lectures * Demos * Code-alongs * Exercises * Quiz |
| **Module 8:**  Deploying EO-based ML Models  **2-3rd June 2023, Digital Transformation Centre, Kigali**  In-person  (16 contact hours) | * Taking ML models into prototyping and production environments * Deployment frameworks and platforms for rapid deployment | Participants will be able to:   * Understand the concept of taking a trained and validated model beyond the academic cradle - and into a real world environment * Be aware of various considerations and concepts involved with deployment (e.g. re-training, designing with the user in mind) * Be familiar with various established deployment frameworks and PaaS platforms for deployment (e.g. Heroku, Streamlit, Anvil, GCP Vertex AI etc) including strengths and weaknesses of each * Complete an exercise in deploying a trained model using one of these frameworks | **Module Reader:**  *Deploying EO-based ML Models*  **Videos / Articles etc.**   * Article: https://paulvanderlaken.com/2020/03/24/ml-model-performance-degradation-production-concept-drift/ * Article: <https://towardsdatascience.com/dont-let-your-model-s-quality-drift-away-53d2f7899c09> * Video: Heroku Explained Icebergs, Lumberjacks, and Condos * Article: https://analyticsindiamag.com/hands-on-guide-to-machine-learning-model-deployment-using-flask/ | Task/content type:   * Reading material * Linked resources * Lectures * Demos * Code-alongs * Exercises * Quiz |
| **Module 9:**  Business model generation and value proposition design (focus on the ML4EO agricultural space)  **4-5th June 2023, Digital Transformation Centre, Kigali**  In-person  (12 contact hours) | * Introduction to business planning/ business model generation * Value proposition * Nine areas of the BMC * Value Proposition Canvas | Participants will be able to:   |  | | --- | |  |  * Compare lean start-up approaches to conventional business planning tools and methods * Explain key concepts of design thinking, business model thinking and key steps in creating a business vision * Explain the building blocks of the Business Model Canvas for value creation. * Apply the Value Proposition Canvas to invent and improve value propositions based on specific customer segments * Apply basic knowledge of the Business Model design process * Map out their own current project/ business idea * Identify systems, resources and processes of existing businesses in the ML and EO sector and reflect on what is needed to deliver services/ products * Prepare the implementation of the project development phase (module 10) | **Module Reader:**  *Session guide*  **Resources**   * Value proposition design * Business model canvas * AI Project Checklist | Reading material  Videos  links to resources  Reflective blogs/ exercises  Live interviews on business model of successful local, regional and international companies / projects operating in ML and EO  Tools: business model canvas, value proposition canvas |
| **Module 10:**  Business Model / Project Development  **16 June – 4th August 2023**  Online  (10 contact hours)  **7th August 2023, Digital Transformation Centre, Kigali**  In-person  (4 contact hours) | * Exercise business model canvases on selected business ideas * Field work to assess market fit and project viability * Verbal presentation / pitch of output / interaction with potential investors * Recap, next steps, and action plan for further development of the model | Participants will be able to:   * Identify, describe, and analyze a practical business opportunity and/or a business already under way (that is relevant in the project context), examining its technical, economic and financial feasibility. * Apply / visualize the business concepts explored in the previous module to selected business ideas in terms of value proposition, segmentation, channels, customer relationships, revenue streams, resources, activities, partnerships, and cost structures * Develop a practical and effective implementation strategy for the proposed business idea/project * Pitch / present their business models * Describe next steps and actions required to develop their project into a minimum viable project |  | Tools: Business Model Canvas, project appraisal checklist  Field work  Face-to-face/ Online coaching  Pitch event |