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2024 ESTORIL - PORTUGAL

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Quality Dimensions of Machine Learning in Official Statistics

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Motivation

- Quality frameworks: Code of Practice & Quality Assurance Framework
- CoP & QAF require official statistics to be "constantly striving for innovation", but are derived from the needs of "traditional" statistics production
- "Innovative" statistical methods can differ substantially from traditional ones:
    - Certain quality dimensions may not be applicable to new methods at all
    - They may be applicable in principle but differ with regards to methodological details
    - New methods may present new challenges that are not covered by existing dimensions

→ Need to **assess the compatibility** of new methods with existing official statistics quality frameworks, and to **offer accompanying quality guidance** when required

How useful is existing quality guidance for ML?

- Many quality principles in the CoP & quality indicators in the QAF are potentially affected by ML methods or can be used to derive quality requirements for their usage (principles for statistical processes and statistical outputs: 7.1-7.7, 8.3-8.5, 9.1, 9.6, 10.2, 10.4, 12.1, 12.2, 13.1, 13.5, 14.2, 15.1, 15.5)
- On the one hand: broad enough to cover methodological characteristics of ML

→ Quality guidance for ML should **build on existing quality frameworks**

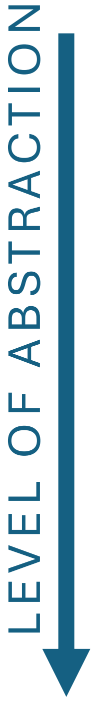
- On the other hand: not specific enough to provide useful guidance in practice

→ Need for developing **quality guidance specifically tailored** to ML

Our approach

- Multi-step process (abstract to specific), analogous to CoP & QAF: quality principles -> quality indicators -> quality methods
- What is needed to ensure compatibility of ML applications used in official statistics production with existing official statistics quality standards?
  1. **Quality dimensions**: What does it mean for ML to have „high quality“?
  2. **Quality guidelines**: How to implement quality along the above dimensions during development?
  3. **Quality indicators & metrics**: How to evaluate quality in development & production?
  4. **Quality documentation**: How to communicate quality of ML in an appropriate, standardised way?
- Work-in-progress: 1. completed, 2. in progress, 3. & 4. pending

Proposed quality dimensions



• Accuracy	*Predictions*	„phenomenon is described correctly“
• **Robustness**	*Model*	„stable results despite small perturbations“
• **Explainability**		„understand how results are generated“
• Reproducibility	*IT infrastructure*	„reproduce identical results“
• Timeliness & Punctuality	*Business processes*	„deliver up-to-date results punctually“
• Cost-effectiveness		„appropriate costs“

+ Cross-cutting issues: **MLOps**, **Fairness**

Robustness

- The degree to which a model produces stable (but useful) results given small perturbations in the environment
- Possible perturbations: outliers in the data, changes in its distribution, violations of model assumptions, structural changes in the observed phenomenon over time (concept drift), or different choices of hyperparameters
- Which “results” should be stable? Plausible candidates:
  - specific predictions (e.g. for influential data points)
  - model coefficients
  - accuracy metrics
  - aggregates that are produced downstream in the statistical production process (e.g. total revenue by industry, export volume by enterprise type)

Fairness

- Aim: to avoid treating certain groups unjustifiably differently in a relevant way by or as a result of statistical procedures (like ML)
- In the context of official statistics, such effects are usually indirect, e.g., through political decisions based on the published data
- Example: statistical aggregates are systematically over- or underestimated for certain sub-groups (e.g., economic sectors, types of households, regions, ...)
- Connections to accuracy (imbalanced data) and explainability

MLOps

- Aim: best possible fulfilment of the quality dimensions
- Necessary: Establishment of standardised processes for data processing, data management and model maintenance
- Strong connections to reproducibility, but also to explainability, timeliness & punctuality and cost-effectiveness

(Of course, we were not the first that stated this for official statistics; see, e.g., Engdahl J, Choi I, Deeben E, Karanka J, Karlsson A, Meszaros M, Pocknee J, Holroyd P, Baily A (2022) Building an ML Ecosystem in Statistical Organisations)

Lessons learned

- Task at hand requires collaboration of ML practitioners, subject-matter statisticians and quality officers
- Must strike a balance between being overly general (and thus not useful) and being too specific (and thus only applicable to certain ML methods)
- Must consider that ML best practices are rapidly evolving
- Theoretical musings are only useful if implemented in practice, ensuring adoption of new standards is of utmost importance!

Thank you

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