Explainable Artificial Intelligence (XAI) Supporting Public Administration Processes – On the Potential of XAI in Tax Audit

Professor Dr. Peter Fettke
Saarland University and German Research Center for Artificial Intelligence (DFKI)

Towards eXplainable Artificial Intelligence (XAI) in Taxation: The Future of Good Tax Governance
University of Amsterdam, Amsterdam Centre for Tax Law

Keynote, Amsterdam, Netherlands, March 10, 2023
Agenda

1. Artificial Intelligence and taxation
2. Explainable Artificial Intelligence (XAI)
3. XAI in tax audit
4. Conclusion and outlook
AI as a plot of Hollywood blockbusters

- **Friendly**
  - K.I.T.T.
    - *Knight Rider*
    - 1982
  - David
    - *A.I. – Artificial Intelligence*
    - 2001

- **Unfriendly**
  - HAL 9000
    - *2001: A Space Odyssey*
    - 1968
  - Red Queen
    - *Resident Evil*
    - 2002

- **Technoid**
  - K.I.T.T.
  - HAL 9000

- **Humanoid**
  - David
  - Red Queen
AI as an academic discipline

Super-AI
General AI
Narrow AI

Robotics

Deep Learning
Machine Learning
AI as state of the art and avantgarde informatics (Dilemma of AI: „As soon as it works, no one calls it AI anymore ...“)

* John McCarthy (1927-2011), one founding father of AI
AI as state of the art: document intelligence

- scan corrections (clipping, rotations, distortions, shadows)
- recognition of document type
- transformation of photo pixels to digital text
- extract relevant information, document classification (business cards, invoices etc.)
- plausibility checks (spelling, anomalies etc.)
AI in the world of taxation: developed prototypes at DFKI

**Understanding**
- Content Analysis and Routing
  - Content analysis and intelligent allocation of tax requests
- Pattern

**Advanced Analytics**
- Duty Rate Prediction
  - Determination of duty rates based on purchase orders
- VAT Determination
  - Neural learning of rules and regulations for VAT

**Insight**
- Visual Analytics
  - Visualization of goods and invoice flows
- Sensitivity Analytics
  - Sensitivity analysis with regard to e.g. transfer prices vs. sales tax

**Automation**
- Cognitive RPA
  - Robot-supported process automation in LTVD-management
- Process compliance & transparency
- Process Mining
  - Use of big data technologies to create process transparency, ensure compliance and generate synergy effects

**Natural Language Processing**
- Q & A
  - Intelligent chatbot for answering free-text tax questions in natural language
- Argumentation
  - Identification of argumentative structures and argumentation patterns in court decisions
- NeuMÜ
  - Neural machine translation of tax-specific texts with technical vocabulary
- Dialog
- Translation
Agenda

1. Artificial Intelligence and taxation
2. Explainable Artificial Intelligence (XAI)
3. XAI in tax audit
4. Conclusion and outlook
XAI as a “hot topic” in core AI research

Source: Artificial Intelligence Index Report 2022, Stanford University
Trustworthy AI has three components, which should be met throughout the system's entire life cycle:

1. it should be **lawful**, complying with all applicable laws and regulations
2. it should be **ethical**, ensuring adherence to ethical principles and values and
3. it should be **robust**, both from a technical and social perspective

XAI is defined as a technical method to ensure that Trustworthy AI principles can be incorporated in the design, development and use phases of an AI system.

XAI history: the concept of explanation is a multi-faceted, non-monolithic

1965: Explanation for expert systems
1970s-1980s: Theoretical and practical foundations for explanations from intelligent systems (driven by IS community and others)
1990s-2000s: Explanations for advanced black-box AI-based systems
2010s-now: Theoretical and practical foundations for explanations from intelligent systems (driven by IS community and others)
Classical architecture (early XAI systems)

XAI idea for machine-learning models

- I understand why
- I understand why not
- I know when you'll succeed
- I know when you'll fail
- I know when to trust you
- I know why you erred

Based on Gunning (2017)
Figure 4: Explaining an image classification prediction made by Google’s Inception neural network. The top 3 classes predicted are “Electric Guitar” ($p = 0.32$), “Acoustic guitar” ($p = 0.24$) and “Labrador” ($p = 0.21$)
Figure 11: Raw data and explanation of a bad model’s prediction in the “Husky vs Wolf” task.

source: Ribeiro et al. (2016)
Agenda

1. Artificial Intelligence and taxation
2. Explainable Artificial Intelligence (XAI)
3. XAI in tax audit
4. Conclusion and outlook
Objective: Explaining ML-based tax decision models

AI-based Solution for Identification of Tax Audit Cases

Explanation of the Black-Box Model and its Outcomes

- Operating expenses
- Total liabilities
- Previous inspections
- Personnel costs
- Travel expenses
- Maintenance costs
- Turnover before taxes
- Assets in the balance sheet

Justification
Strategy Development
Plausibility of Decisions
AI-Fairness
Compliance
Verification

Auditor
Management
Citizens
Judicial instances
Regulators
Developers

source: Mehdiyev et al. (2021)
Decision prediction

work case | resource | sensor

work sequence | execution time
Decision prediction

- work case
- resource
- sensor
- work sequence
- execution time

process drift

result: risk, anomaly, error?

next workflow step

prediction of process indicators (time, costs, quality)

time

past

T

future
Decision prediction using deep learning

Predicting process behaviour using deep learning

Jorg Evermann,†, Jana Rebecca Rehbe,‡, Peter Fietisch

1. Introduction

1.1. Background

1.2. Motivation

1.3. Research gap

2. Literature review

2.1. Process mining

2.2. Decision making

3. Methodology

3.1. Deep learning

3.2. Evaluation

4. Results

4.1. Model accuracy

4.2. Model robustness

5. Discussion

5.1. Interpretability

5.2. Limitations

6. Conclusion

7. Future work

source: Evermann et al. (2021)
XAI-framework for explaining ML-based tax decisions

based on: Mehdiyev, Fettke (2009) and Mehdiyev et al. (2021)
Explanation of feature importance

source: Mehdiyev et al. (2021)
More explanation approaches

Individual Conditional Expectation (ICE) Plots

Shapley Values

LIME

Partial Dependence Plots (PDP)

source: Mehdiyev et al. (2021)
Agenda

1. Artificial Intelligence and taxation
2. Explainable Artificial Intelligence (XAI)
3. XAI in tax audit
4. Conclusion and outlook
Guidelines for understanding and designing XAI tax systems

Guideline I: Develop tax model
• Model architecture of tax system
• Model tax data
• Model tax processes

Guideline II: Communicate explanations
• Design specific user interfaces for XAI-powered solutions
• Incorporate findings from cognitive sciences to transfer the generated explanations effectively
• Explore relevant provision mechanisms considering process characteristics

Guideline III: Generate and evaluate explanations
• No “one fits all” XAI solution
• Explanation generation and evaluation should be approached more holistically, considering users’ mental models, situation context, and other relevant aspects

Guideline IV: Develop and evaluate machine learning model
• Interpretable models should be first explored and used if they are capable of delivering relevant outcomes
• Need for a black-box model should be checked in terms of business and technical success criteria

based on: Fettke, Mehdiyev (2022)
TaxTech – The fourth discipline of taxation and the TaxTech-House of the digital tax function for *good tax governance*

I Methological Foundations
- terminology, taxonomy, modelling, architecture

II Technical Basic Systems
- Database systems, non-standard-database systems, workflow-systems

III Data Analytics
- statistical data analysis, multidimensional data analysis, Data Mining, Text Mining, Process Mining

IV Intelligent Systems
- knowledge-based systems, learning systems, systems for anomaly detection, dialogue- and assistance systems, systems for robot-supported process automation

V Innovation and Technology-Radar
- Blockchain, AI-maturity models, best-practices, business models

VI Management
- strategy, process management, selection- and implementation of standard software, process innovation

source: Fettke (2019)
Thank you for your attention!

Contact
Professor Dr. Peter Fettke
German Research Center for Artificial Intelligence (DFKI) and
Saarland University
Campus D 3 2
66123 Saarbruecken, Germany
peter.fettke@dfki.de, http://www.dfki.de
Phone: +49 681 85775-5142, Fax: -3696