AI, FINANCIAL TECHNOLOGY, RISK MANAGEMENT AND REGULATION

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Firamis acknowledges the NVIDIA Inception DACH program for the computational GPU resources for use case and product development.

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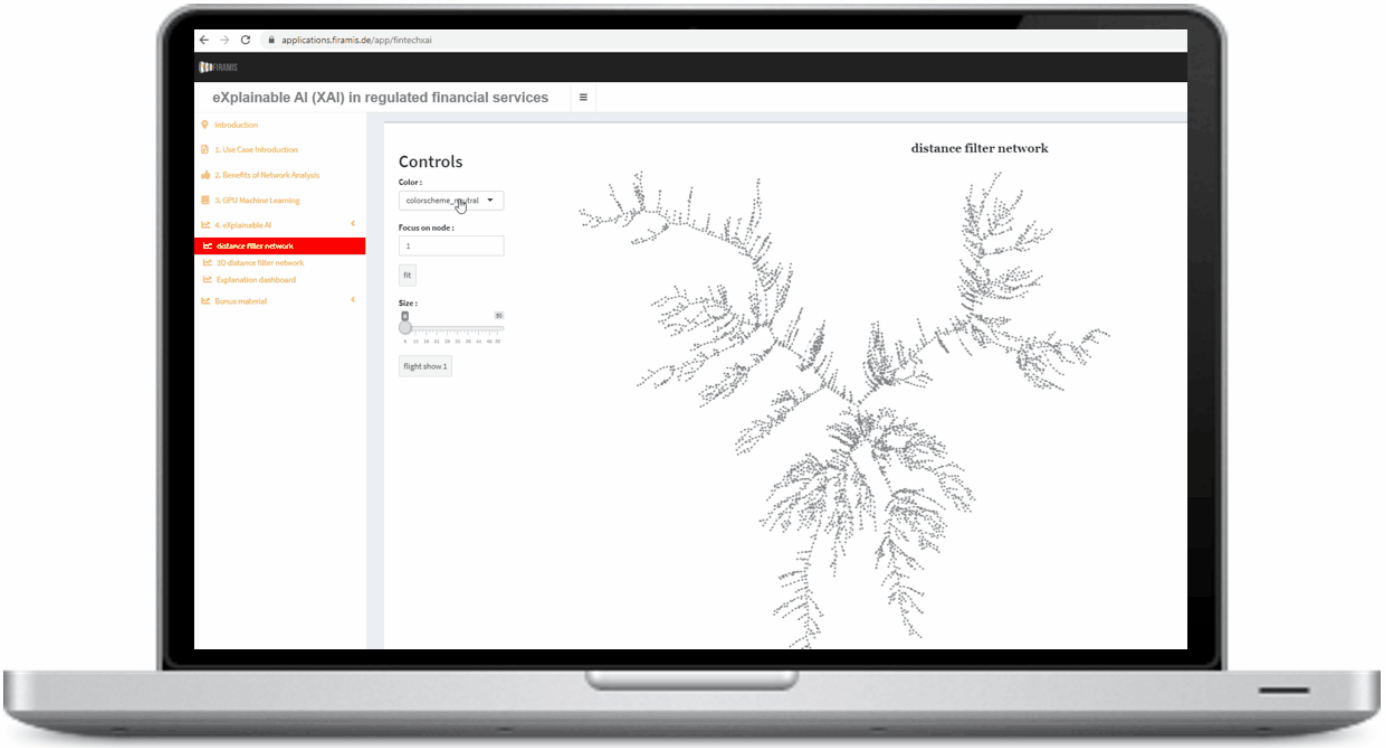
1 The EU Horizon2020 FIN-TECH project



Visualising the 'brain' of an arbitrary (black-box) AI model. Explainable AI is one of the key technologies for human-centric, trustworthy and responsible AI made in Europe. Among others there are two focus areas in this EU Horizon2020 project and also in the fintech company Firamis GmbH: Graph analytics and eXplainable AI (XAI). Nodes are customers of a credit portfolio. The links connect similar AI-decision-making for groups of customers. Similar decision making is color coded in the nodes.

FIN-TECH is a program for FINancial supervision and TECHnology compliance training, funded by the EC (https://www.fintech-ho2020.eu (https://www.fintech-ho2020.eu)) with a budget of 2.5 Mio € and the involvement of numerous Universities, Supervisors, Banks and Fintechs (hubs) across Europe. The project focuses on AI, Big data analytics and blockchain technology for applications in credit assessment, p2p lending, market risk management, robo advisory and crypto investing.

In this article we highlight some of the focus areas and outcomes of this project. Also, we outline the activities and engagements in this project of our Frankfurt-based AI and Financial Technology company 'Firamis GmbH'. Later in the text we inform about some of the major programs and activities of the EU with respect to 'AI and Fintech'. In the last part we inform about some recent activities in Hessen and Frankfurt.

In the project we identified the focus areas 1) graph analytics to reveal and explain complex, hidden relationships in financial (transaction) data and 2) eXplainable AI (XAI) for human-centric, trustworthy, responsible AI and its adoption. Clearly, the potential of the presented modeling approaches like XAI and Graph Analytics is huge and many users in Banks, Insurance companies and Asset Management firms will benefit from them. This is what the EU project has received as feedback during the evaluation process that the project has in place.

Recently, there have been many publications on eXplainable AI. It can solve the black box problem of AI models which is key for mission critical AI applications e.g. strongly regulated industries like financial services. Here some interesting findings on XAI:

- Bank of England: 'Machine learning explainability in finance: an application to default risk analysis' https://www.bankofengland.co.uk/working-paper/2019/machine-learning-explainability-in-finance-an-application-to-default-risk-analysis (https://www.bankofengland.co.uk/working-paper/2019/machine-

learning-explainability-in-finance-an-application-to-default-risk-analysis)

- FCA: 'Explaining why the computer says 'no" https://www.fca.org.uk/insight/explaining-why-computer-says-no (https://www.fca.org.uk/insight/explaining-why-computer-says-no)
- Joint Research Centre (JRC), the European Commission's science and knowledge service: 'Robustness and Explainability of Artificial Intelligence' https://publications.jrc.ec.europa.eu/repository/bitstream/JRC119336/dpad_report.pdf (https://publications.jrc.ec.europa.eu/repository/bitstream/JRC119336/dpad_report.pdf)
- FCA: 'AI transparency in financial services – why, what, who and when?' https://www.fca.org.uk/insight/ai-transparency-financial-services-why-what-who-and-when (https://www.fca.org.uk/insight/ai-transparency-financial-services-why-what-who-and-when)
- Bank of England: 'Shapley regressions: a framework for statistical inference on machine learning models': https://www.bankofengland.co.uk/-/media/boe/files/working-paper/2019/shapley-regressions-a-framework-for-statistical-inference-on-machine-learning-models.pdf (https://www.bankofengland.co.uk/-/media/boe/files/working-paper/2019/shapley-regressions-a-framework-for-statistical-inference-on-machine-learning-models.pdf) We have produced an own paper that is mathematically related to this work: 'Explainable AI in Credit Risk Management' https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3506274 (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3506274)
- European Commission: 'White paper on Artificial Intelligence - A European approach to excellence and trust' https://ec.europa.eu/info/sites/info/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf (https://ec.europa.eu/info/sites/info/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf)
- FCA: 'The future of regulation: AI for consumer good' https://www.fca.org.uk/news/speeches/future-regulation-ai-consumer-good (https://www.fca.org.uk/news/speeches/future-regulation-ai-consumer-good)
- Ethics Guidelines for Trustworthy Artificial Intelligence (AI) is a document prepared by the High-Level Expert Group on Artificial Intelligence (AI HLEG) https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=60419 (https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=60419)
- "Explainability of a Machine Learning Granting Scoring Model in Peer-to-Peer Lending" (also from the FIN-TECH project) https://ieeexplore.ieee.org/document/9050779 (https://ieeexplore.ieee.org/document/9050779)

XAI and Graph Analytics are some of the most trending approaches, currently becoming very relevant in the financial service industry, both for regulatory and economical reasons. This is underlined by the conclusion of Gartner that graph analytics and XAI will be some of the most trending technologies in the next years (https://www.gartner.com/smarterwithgartner/gartner-top-10-data-analytics-trends/ (https://www.gartner.com/smarterwithgartner/gartner-top-10-data-analytics-trends/)).

Risk managers in financial institutions are asking increasingly complex questions across structured and unstructured data, often blending data from multiple applications, and increasingly, external data. Graph analytics is a set of analytic techniques that shows how entities such as people, places and things are related to each other. Applications of graph analytics in risk management cover credit scoring/assessment, (crypto) market risk, cyber risk, model risk and enable advanced approaches to risk management disciplines like early warning, stress testing and data-driven nowcasting. Especially in times of crisis like Corona, it is important to understand temporal changes, shifts, contagion and trends based on available data in order to identify and address new and emerging areas of risk.

XAI is being adopted worldwide at the moment:

- companies like McKinsey, Microsoft, Google and IBM have come up with XAI software and services
- large international conferences like NIPS and ICML started to cover XAI-related topic at a substantial level
- In February 2020, the European Commission published a White Paper on Artificial Intelligence (AI), formulating two goals: achieving an ecosystem of excellence in AI, and creating an ecosystem of trust. In other words: boosting innovation and securing protection. This comes in addition to the work of the High-Level Expert Group on AI, which produced Europe's Ethics Guidelines for Trustworthy AI and deliver a comprehensive vision for AI governance. Among the requirements for Trustworthy AI one can see that XAI is a major building block.

Without acceptable explanation, auto-generated insights or "black-box" approaches to AI can cause concerns about regulation, reputation, accountability and model bias. Responsible AI in financial services is connected to governance and risk management, driving transparency and accountability to mitigate AI risks. Effective risk management, far from being an inhibitor of innovation, is in fact pivotal to a firm's successful adoption of AI.

Within this project we have published several papers on XAI in credit and fintech risk management:

- https://www.frontiersin.org/articles/10.3389/frai.2020.00026/full (https://www.frontiersin.org/articles/10.3389/frai.2020.00026/full)
- https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3506274 (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3506274)

We were also able to adapt the XAI approach to investment risk management where we implemented a machine-learning-based approach together with the Trading and Hedging Team at Munich Re: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3528616 (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3528616). The system is able to identify robust portfolio construction strategies with respect to certain market states.

Firamis is multiple workpackage leader and member of the executive board of the FIN-TECH project. One of the task was to build an entire central platform for the communication and knowledge transfer. Almost a dozen use cases had been developed by the partners including code to be executed on the platform, providing an open-source-based infrastructure with minimal entry barriers (only a browser and internet connection is needed). A use case training 24/7 is enabled as well as joint training dessions with several dozen users. The platform also supports the broad dissemination, training and use case evaluation activities. Numerous supervisors, regulators, banks and fintech hubs are involved. The technology behind the platform can be studied here: https://firamis.de/Firamis_Flyer_Data_Science_Platform.pdf (https://firamis.de/Firamis_Flyer_Data_Science_Platform.pdf). Some of the use cases are on XAI.

We have discussed the FIN-TECH use cases in workshops with several banks and fintechs across Europe as well as with:

- the 3 European supervisory authorities ESMA, EBA and EIOPA
- the ECB
- many national supervisors/regulators in most of the EU contries
- the international non-European advisors of the project.

Firamis has also organised a special event in Brussels where we presented the XAI approaches and invited guests and speakers from industry, regulation, supervision for speaking and discussion. ECB and EBA presented their latest publications on BDA, AI, and Fintech risk management.

Explainable AI (XAI) increases the transparency and trustworthiness of AI solutions and outcomes, reducing regulatory and reputational risk. Explainable AI is the set of capabilities that describes a model, highlights its strengths and weaknesses, predicts its likely behavior and identifies any potential biases.

Explainability is motivated due to lacking transparency of so-called black-box approaches, which do not foster trust and acceptance of AI generally and ML specifically. Rising legal and privacy aspects, e.g. with the new European General Data Protection Regulations (GDPR) will make black-box approaches difficult to use in Business, because they often are not able to explain why a machine decision has been made. Consequently, the field of XAI is recently gaining international awareness and interest because raising legal, ethical, and social aspects make it mandatory to enable – on request – a human to understand and to explain why a machine decision has been made.

Our following presentation gives an in-depth view on XAI:

The event took place in the Representation of the State of Hessen to the EU and Firamis was supported in the event organisation by the European Banking Federation (https://www.ebf.eu/ (https://www.ebf.eu/)) and by the Enterprise Europe Network (https://een.ec.europa.eu/ (https://een.ec.europa.eu/)).

Press releases can be found here: https://www.linkedin.com/feed/update/urn:li:activity:6610227212710879232/ (https://www.linkedin.com/feed/update/urn:li:activity:6610227212710879232/) https://www.linkedin.com/feed/update/urn:li:activity:6607660691367223296/ (https://www.linkedin.com/feed/update/urn:li:activity:6607660691367223296/)

Dr. Fritz-Morgenthal from Bain & Company moderated a panel discussion, where Dr. Neu from DZ Bank was one of the panelists. Together they wrote the following summary about this expert workshop: https://www.linkedin.com/pulse/big-data-analytics-artificial-intelligence-sebastian-fritz-morgenthal/ (https://www.linkedin.com/pulse/big-data-analytics-artificial-intelligence-sebastian-fritz-morgenthal/)

We perceived a broad interest in the potential of approaches like XAI and Graph Analytics and we can expect that future policies might incorporate such trustworthy AI initiatives.

As foreseen in the FinTech Action Plan, the Commission has also set up a EU Fintech Lab. The EU FinTech Lab provides a regulators' forum to discuss regulatory and supervisory issues regarding new technological applications that are on the market with experts. The Lab has met four times so far (1x cloud, 2x artificial intelligence, 1x RegTech/SupTech), the last time in December 2019 (on AI)."

At the recent event Firamis has also presented their approach on XAI and Graph Analytics. It could be observed that most other Fintech companies also presented on XAI which showed once more that this topic is to stay and becomes very relevant.

Already since 2012 Firamis has been involved in Graph Analytics and XAI for the financial services industry, well anticipating the developments.

Our research and publications cover these topics (https://firamis.de/events_and_publications/ (https://firamis.de/events_and_publications/) and our SSRN page: https://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=2040577 (https://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=2040577)) as well as our solutions:

- InvestTech: https://www.firamis.de/Firamis_Flyer_XAIVEST.pdf (https://www.firamis.de/Firamis_Flyer_XAIVEST.pdf)
- RiskTech: https://www.firamis.de/Firamis_Flyer_XAI_for_Risk_Management_and_Fraud_Detection.pdf (https://www.firamis.de/Firamis_Flyer_XAI_for_Risk_Management_and_Fraud_Detection.pdf)
- Consulting & Solutions: https://firamis.de/Firamis_Flyer_XAI_Consulting_and_Solutions.pdf (https://firamis.de/Firamis_Flyer_XAI_Consulting_and_Solutions.pdf)

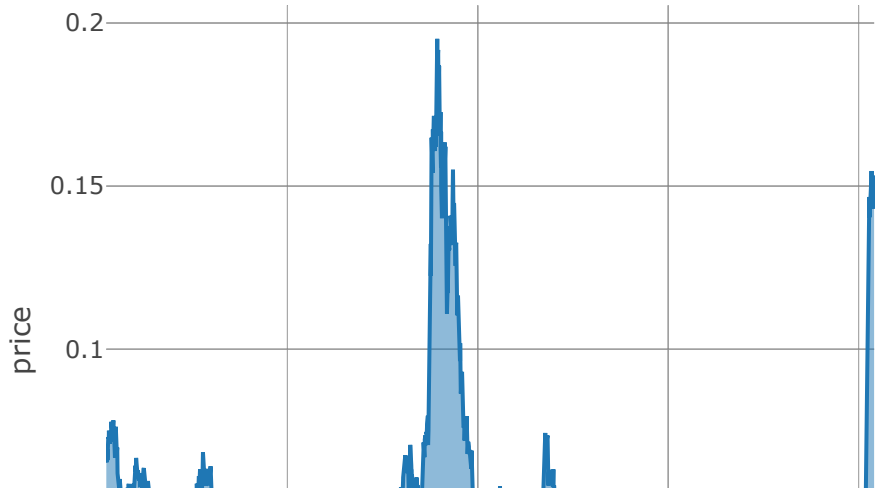
In the FIN-TECH project there have been several innovative approaches to market risk management. Firamis was allowed to develop interactive dashboards to demonstrate the potential of the approaches as can be seen in the following 2 applications:

Financial Risk Meter

- The Financial Risk Meter (FRM) helps you to identify different systemic risk level in different financial markets over time. Input data is just market and macro data.
- The risk evaluation of capital market data facilitates investment and lending decisions and allows to monitor even large portfolios permanently. FRM thus enables efficient and proactive risk management. It is an early warning system for emerging risk and recession.
- In this application you see FRM for different markets: US/EU financial institutions, CDS rates, bond rates/yields, crypto coins.
- FRM uses linear lasso measures to estimate systemic interconnectedness across marekts based on tail-driven spill-over effects in an ultra-high dimensional framework. Methodologically, we employ a variable selection technique in a time series setting for a linear quantile regression framework with 5% quantile. We can thus include more markets into the analysis, to measure their interdependencies in tails.

Americas | Europe | Asia | Euro Rates | Crypto | Itraxx SenFin

US S&P 500



More information about the FIN-TECH project as well as about AI and Financial Technology can be found in our journal:

Fintech Risk Management: A Research Challenge for Artificial Intelligence in Finance https://www.frontiersin.org/articles/10.3389/frai.2018.00001/full (https://www.frontiersin.org/articles/10.3389/frai.2018.00001/full)

Editorial: AI and Financial Technology https://www.frontiersin.org/articles/10.3389/frai.2019.00025/full (https://www.frontiersin.org/articles/10.3389/frai.2019.00025/full)

2 EU activities with regards to Artificial Intelligence in Fintech

One of the best and most up-to-date overviews on the European approach to Artificial Intelligence in Fintech can be found in this report by Pēteris Zilgalvis (Head of Unit, Digital Innovation and Blockchain, Digital Single Market, DG CONNECT; Co-Chair, FinTech Task Force, EC), page 158 ff.: https://www.eurofi.net/wp-content/uploads/2020/04/views-the-eurofi-magazine_zagreb_april-2020.pdf (https://www.eurofi.net/wp-content/uploads/2020/04/views-the-eurofi-magazine_zagreb_april-2020.pdf)

For your convencience we have extracted some paragraphs here:

"There are prominent synergies between Artificial Intelligence (AI) and the financial services sector as emerging technologies rapidly extend their impact on the financial industry. This reality is reflected in and addressed by the European Commission’s new Digital Strategy (2020), the European Data Strategy (2020), the White Paper On

Artificial Intelligence - A European approach to excellence and trust (2020), the SME Strategy (2020), the eIDAS Regulation, Payment Services Directive 2 as well as nonlegislative financial services initiatives such as the FinTech Action Plan (2018).

Europe is well-positioned to tap into the potential of AI by capitalising on Europe's competitive industrial and professional markets, including financial services, and its digital innovation and research capacities. At the same time, building an ecosystem of trust is essential. A European approach to AI should ensure that machine-based learning technologies are human-centric, ethical, sustainable and respect fundamental rights and values.

It is important to recognize that while AI can do much good, including by providing better access to finance, reduce costs, and increase efficiency, it can also have negative impacts. It is therefore imperative to mitigate unintended consequences, in particular the risks of data bias, which may arise in the financial services and other sectors. The integrity of the data is paramount, as is the design of AI applications with fundamental rights protections in mind (especially personal data and privacy protection, and non-discrimination).

The Commission is addressing these challenges through a variety of efforts and initiatives, including providing guidance in its AI strategy (2018), Coordinated Plan with the Member States, the Guidelines on Trustworthy AI published by the HighLevel Expert Group (2019), and most recently the Commission White Paper on Artificial Intelligence (2020)."

In February 2020, the European Commission published a White Paper on Artificial Intelligence (AI), formulating two goals: achieving an ecosystem of excellence in AI, and creating an ecosystem of trust. In other words: boosting innovation and securing protection. This comes in addition to the work of the High-Level Expert Group on AI, which produced Europe's Ethics Guidelines for Trustworthy AI and deliver a comprehensive vision for AI governance. Among the seven requirements for Trustworthy AI one can see that XAI is a major building block.

Margrethe Vestager's (executive vice president of the European Commission for a Europe Fit for the Digital Age) plan to use regulation to restore trust in technology—starting with artificial intelligence. (https://www.bloomberg.com/news/articles/2020-04-07/europe-s-tech-czar-says-strict-ai-rules-will-build-public-trust (https://www.bloomberg.com/news/articles/2020-04-07/europe-s-tech-czar-says-strict-ai-rules-will-build-public-trust)). When Vestager unveiled her proposal in February to regulate AI, she said the EU wants to embrace the benefits the technology brings while also tackling its risks. Her approach is to focus regulation on the applications that affect people's lives or legal status. The goal is to ensure that citizens have confidence in how AI is used and developed so people embrace it fully, she says. Without acceptable explanation, auto-generated insights or "black-box" approaches to AI can cause concerns about regulation, reputation, accountability and model bias. Responsible AI in financial services is connected to governance and risk management, driving transparency and accountability to mitigate AI risks. Effective risk management, far from being an inhibitor of innovation, is in fact pivotal to a firm's successful adoption of AI.

More information on the EU inveiling their AI and data strategy can be found here:
https://fintechnews.ch/aifintech/european-commission-unveils-ai-data-strategy/33353/
(https://fintechnews.ch/aifintech/european-commission-unveils-ai-data-strategy/33353/)

There are 30 recommendations on regulation, innovation and finance in this report by the Expert Group on Regulatory Obstacles to Financial Innovation (ROFIEG):
https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/191113-report-expert-group-regulatory-obstacles-financial-innovation_en.pdf
(https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/191113-report-expert-group-regulatory-obstacles-financial-innovation_en.pdf)

"In the concluding chapter of this report, we indicate our top Recommendations in terms of regulatory reform, highlighting the need to address as a matter of priority: – The explainability and interpretability of technology, especially AI, as measures to protect consumers and businesses and facilitate supervision, or to meet supervisory

expectations (Recommendation 1)

[…] Recommendation 1 – Explainability and interpretability of AI and associated technologies The Commission should, in co-operation with the ESAs and relevant international standardsetting bodies:

- develop measures clarifying the circumstances under which requirements aiming at explainability or interpretability of AI and associated technologies, in their concrete applications, are appropriate, considering the need for sector-specific or horizontal rules;
- provide guidance on how to meet explainability and interpretability requirements, where applicable, in respect of different stakeholders, including consumers and supervisors, acknowledging that different standards will be needed depending on the type of application for which the relevant technology is being used

[…] The issue of explainability is to some extent addressed in Article 13 GDPR, which requires firms to inform their customers about the existence of automated decision-making processes, as well as to provide them with meaningful explanation regarding the logic involved and the significance and envisaged consequences of such processing, differentiating between different stakeholders, e.g. regulators or consumers.

[…] As for other technologies, supervisors face challenges to keep pace with the industry in terms of knowledge and understanding of AI, Big Data, machine learning and DLT/blockchain solutions and their application in the financial sector. Supervisors may not necessarily have the level of expertise required to comprehensively assess whether an innovative solution should be permitted, whether to respond with appropriate guidance or rules setting out clear expectations, for instance in terms of auditability, explainability, governance and operational resilience, or how to challenge firms consistently and effectively in the course of day-to-day supervision. For these reasons, supervisors have developed innovation facilitator initiatives to help enhance monitoring and engagement with industry on innovation related issues, and the ESAs are taking steps to promote more in-depth and common understanding of new technologies, for instance via the European Forum for Innovation Facilitators (EFIF)35 and the EBA's FinTech Knowledge Hub."

Further links: Digital finance and the Commission's action plan on FinTech: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/digital-finance_en (https://ec.europa.eu/info/business-economy-euro/banking-and-finance/digital-finance_en)

Besides FIN-TECH there are other very interesting projects on the topic like INFINITECH and FINSEC: https://www.infinitech-h2020.eu/ (https://www.infinitech-h2020.eu/) und https://www.finsec-project.eu/ (https://www.finsec-project.eu/)

3 What is happening in Frankfurt/Hessen?

'Artificial Intelligence (AI) in the Financial Sector—Potential and Public Strategies' Stephan Bredt, Ministry of Economics, Energy, Transport and Housing of the State of Hessen, Wiesbaden, Germany https://www.frontiersin.org/articles/10.3389/frai.2019.00016/full (https://www.frontiersin.org/articles/10.3389/frai.2019.00016/full)

Gaia-X: Digital development without sacrificing European values, data autonomy and regulatory/legal concepts. https://www.bigdata-insider.de/mit-gaia-x-zur-europaeischen-datenautonomie-a-895779/ (https://www.bigdata-insider.de/mit-gaia-x-zur-europaeischen-datenautonomie-a-895779/)

Interview of Dr. Jochen Papenbrock by Frankfurt Main Finance on Frankfurt as a financial center embracing AI https://frankfurt-main-finance.com/en/the-financial-centre-frankfurt-has-great-chances-to-become-the-european-capital-of-financial-technologies/ (https://frankfurt-main-finance.com/en/the-financial-centre-frankfurt-has-great-chances-to-become-the-european-capital-of-financial-technologies/)

AI in Financial Services Association of AI in Financial Services e.V.: Founding members are Andreas Lukic (director of Business Angels FrankfurtRheinMain), Prof. Hans-Gert Penzel (ibi research at Regensburg University GmbH), Prof. Dr. Philipp Sandner (Frankfurt School Blockchain Center) and Sascha Borchert (Sonderbeauftragter Digitalisierung at R-V Versicherung) https://www.aiinfs.com/ (https://www.aiinfs.com/)

Frankfurt Institute for Risk Management and Regulation

AI Roundtable is headed by Dr. Fritz-Morgenthal, Bain & Company and Dr. Jochen Papenbrock, Firamis https://www.firm.fm/en.html (https://www.firm.fm/en.html)

Frankfurt Digital Finance https://frankfurt-digital-finance.de/speakers/jochen-papenbrock/ (https://frankfurt-digital-finance.de/speakers/jochen-papenbrock/) https://frankfurt-digital-finance.de/wp-content/uploads/galerie/B_FDF-1305-9112.jpg (https://frankfurt-digital-finance.de/wp-content/uploads/galerie/B_FDF-1305-9112.jpg)

Frankfurt School Blockchain Center (FSBC) at the Frankfurt School of Finance & Management https://www.frankfurt-school.de/home/research/staff/Philipp-Sandner (https://www.frankfurt-school.de/home/research/staff/Philipp-Sandner)

AI Frankfurt Rhein-Main https://www.ai-frankfurt.de/ (https://www.ai-frankfurt.de/)

Startup and Fintech community, ecosystem for financial technology and AI https://techquartier.com/ (https://techquartier.com/)

4 Enterprise adoption of AI in financial institutions

There are several important factors for a wider adoption of XAI and Graph Analytics in the financial services industry:

- The speed, agility, accuracy and performance of the system (hardware and software) needs to be ready for production. Therefore, a modeling architecture needs to be in place that makes use of modern infrastructures for high-performance (like GPUs) and cloud computing. This enables processing larger amounts of data in parallel with low latency and throughput time.
- most suitable open-source software environments/projects/packages need to be identified that can be managed for production and that scale well with the available hardware and environment.
- There need to be suitable visualization and interactive dashboards of the data and models as visual interfacing is one of the core ideas of graph analytics and XAI.
- The cost of corresponding productive systems needs to be estimated and optimized.
- processes for AI governance, risk management, audit and reporting need to be in place.

Best configurations and set-ups of hardware and software need to be found and assembled into a workflow and cloud-based platform with interfacing dashboards – based on the existing cloud-based FIN-TECH platform as a very good starting point. This will reduce their implementation cost and improve their risk management of new technologies.

This is further evalaborated in this article: https://news.developer.nvidia.com/introduction-to-gpu-accelerated-python-for-financial-services/ (https://news.developer.nvidia.com/introduction-to-gpu-accelerated-python-for-financial-services/)

The Firamis approaches to XAI in credit risk and investment risk management (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3528616 (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3528616); https://www.frontiersin.org/articles/10.3389/frai.2020.00026/abstract (https://www.frontiersin.org/articles/10.3389/frai.2020.00026/abstract) / https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3506274 (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3506274)) have also been improved by using GPU- and cloud infrastructures. Firamis acknowledges the NVIDIA Inception DACH program for the computational GPU resources for use case and product development.

5 Bonus material: AI governance and compliance check lists for supervisors

questions to the Board of Management of a supervised financial institution:

- What is the AI footprint of the company?
- Does the board of directors have any supervision over the use of AI by the company?
- If so, what is the specific expertise that enables the board to oversee the use of AI?
- How does the board of directors oversee the use of AI? What are the relevant board reports?
- Does the company have a list of AI governance principles? If so, how are they implemented? How does the board of directors ensure that these principles are appropriate and are actually implemented?
- Does the board have the appropriate skills and expertise to monitor the risks and opportunities arising from AI? If not, does it at least have access to such skills and expertise?
- Does the company engage in discussions with policy makers and other relevant stakeholders on AI governance?

5.1 Model check list

5.1.1 Checklist for Supervisors/Regulators and Banks Model checkers

(A list of all the risks and problems that must be considered when applying and establishing complicated BDA and AI models.)

5.1.2 Model itself

- Does your model fulfill the requirements of the definitions of transparency and explainability
- Does your model fulfill the requirements of the definition of human-interpretable interpretations (HII) of a model's decision policies?
- Could the information which arised from your model be easily shared with peers (analysts, managers, data scientists, data engineers)?
- Does your model meet the following criteria? o account for fairness (unbiasedness/non-discriminative), o accountability (reliable results), o transparency (being able to query and validate predictive decisions) of a

predictive model — currently in regard to supervised learning problems.

5.1.3 Who should be involved?

- Are you aware of the stakeholder you are addressing with the explanation of your model? o Developers, i.e. those developing or implementing an ML application; o 1st line model checkers, i.e. those directly responsible for making sure model development is of sufficient quality; o management responsible for the application; o 2nd line model checkers, i.e. staff that, as part of a firm's control functions, independently check the quality of model development and deployment; o conduct regulators that take an interest in deployed models being in line with conduct rules; o prudential regulators that take an interest in deployed models being in line with prudential requirements.

5.1.4 Explaining

- Are you able to explain and validate the ML-models predictions?
- Regarding the stakeholders you want to address, are you able to answer the following questions?

1. Which features mattered in individual predictions?
2. What drove the actual predictions more generally?
3. What are the differences between the ML model and a linear one?
4. How does the ML model work?
5. How will the model perform under new states of the world? (that aren't captured in the training data) o This could be answered by testing the model with different simulations

- Can you identify the factors which are important for making specific predictions and help to understand the logic behind a model's operation?
- Definition Black Box problem: The explainability problem of AI contains the problem of only studying the inputs and the outputs of a machine learning model, but not its inner workings.
- Helpful definitions that apply to explainable ML have been put forward, including: o Interpretable: "The ability to explain or to present in understandable terms to a human o A Good Explanation: "When you can no longer keep asking why"
- The complexity of ML models makes it difficult to explain their operation to humans.
- information should be easily shared with peers (analysts, managers, data scientists, data engineers).
- Explanation and validation of the ML-models predictions
- Identification of the factors which are important for making specific predictions and help to understand the logic behind a model's operation?
- Explanations can answer different kinds of questions about a model's operation depending on the stakeholder they are addressed to. So it is important to define which stakeholders should be addressed with the explanation

5.1.5 Legal

- Does your software belong to an application area of ML-Software where a broader interpretability might be legally necessary? - There are several legal paragraphes which could be relevant (13, 14 and 15 GDPR) – do you fulfill the requirements? What is the definition of human-interpretable interpretations (HII) of a model's decision policies?

- ML models often don't fulfill the following criteria: o account for fairness (unbiasedness/non-discriminative), o accountability (reliable results), o transparency (being able to query and validate predictive decisions) of a predictive model — currently in regard to supervised learning problems.
- Software could face areas of ML-Software where a broader interpretability might be legally necessary (e.g. 13, 14 and 15 GDPR) – do you fulfill the requirements?

6 More literature

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- List of publications and events
- SSRN page of Dr. Jochen Papenbrock: https://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=2040577 (https://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=2040577)
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ABOUT US

Firamis is a B2B FinTech company est. 2012 near Frankfurt. Clients are banks, asset managers, insurance companies and other financial institutions. Solution types include InvestTech, WealthTech,RiskTech and RegTech. Firamis is supported by the EU ('Horizon 2020'). Firamis co-organizes the yearly https://ai-bigdata.network (https://ai-bigdata.network), a special conference on Artificial Intelligence, Big Data and Network Analysis in Financial Services.

Firamis recently won 2 EU-Grants. Since Septebmer 2018 Firamis is home to Dr. Dimitri Marinelli, who has been awarded the Marie-Curie Individual Fellowship. Together with Firamis he works on the backreaction of the financial market to risk propagation.

Starting in 2019, Firamis will be part of a European consortium of various Universities and Fintechs with the common goal to implement FIN-Tech: a FINancial supervision and TECHnology compliance training programme. Firamis will i.a. be responsible for the mutual coding-platform. See https://www.fintech-ho2020.eu/ (https://www.fintech-ho2020.eu/).

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