2024-03-05

Application

Gionis, Aristides

Information about applicant

Project leader: Aristides Gionis

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Project site: CS - Theoretical Computer Science

Information about application

Call name: Distinguished professor grant in Natural and Engineering Sciences 2024 (Natural and Engineering Sciences)

Type of grant: Distinguished Professor Grant

Focus: Natural and engineering sciences

Call for proposals subject area: NE

Project title: Diversity and fairness in information-access systems

Project start: 2025-01-01

Project end: 2032-12-31

Review panel applied for: NT-RPKON-4

Classification code: 10202. Information Systems (Social aspects to be 50804), 10201. Computer Sciences

Keywords: Diversity algorithms, Algorithmic fairness, Recommender systems, Approximation algorithms

Funds applied for

Year:	2025	2026	2027	2028	2029	2030	2031	2032
Amount:	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000

Total amount applied

32,000,000

Project information

Project title (Swedish)

Mångfald och rättvisa i system för informationsåtkomst

Project title (English)

Diversity and fairness in information-access systems

Abstract and popular science description

Abstract (English)

In this project we will develop novel computational methods for searching and exploring large amounts of data in modern information-access systems. Our methods will empower individuals to find information that caters for their needs, whether those are for education, entertainment, or decision-making purposes, while maximizing diversity of information and ensuring fairness of the presented content. Incorporating these principles into information-seeking methods helps mitigating biases and avoiding blind spots, which are created by machine-learning methods that often aim to maximize solely user satisfaction or user engagement. Among different types of information systems we will focus on three domains: information-exploration systems, information networks, and two-sided information markets.

The project has foundational nature and aims to establish a unified framework and common methodologies for studying diversity and fairness in the different settings. Potential breakthroughs include introducing novel models, applying novel computational approaches to these problems, and developing methods with theoretical guarantees. The project will employ three PhD students and three two-year postdocs, in addition to 50% time allocated by the PI. The project also aims to consolidate research on the foundations of data science in the computer-science department of KTH and create an internationally prominent hub in this field.

Popular science description (Swedish)

I dagens digitala tidsålder översvämmas vi av ett konstant flöde av data från olika källor som sociala medier och nyhetskanaler. För att. navigera i detta överflöd av data är maskininlärningsalgoritmer utformade för att prioritera och filtrera det innehåll som mest sannolikt är förenligt med individers uppfattningar. Sådana algoritmer tenderar dock att förstärka befintliga fördomar och skapa blinda fläckar. Det är därför viktigt att skapa metoder som gör det möjligt för användare att hitta relevant innehåll i informationsåtkomstsystem, samtidigt som de uppfyller kriterierna för mångfald och rättvisa. Mångfald innebär att exponera användarna för olika perspektiv, medan rättvisa säkerställer rättvis tillgång till information. Att inkludera dessa principer hjälper till att mildra fördomar och främja en välbalanserad förståelse av ämnen.

I detta projekt kommer vi att utveckla teoretiska grunder och nya abstraktioner för att studera frågor om mångfald och rättvisa i moderna system för informationsåtkomst. Bland olika typer av informationssystem kommer vi att fokusera på tre scenarier: informationsutforskningsuppgifter, informationsnätverk och tvåsidiga informationsmarknader. Vi kommer att försöka skapa ett enhetligt ramverk och gemensam metodologi för att studera mångfald och rättvisa i de olika miljöerna. Stor vikt kommer att läggas på att designa algoritmer som inkluderar modeller för användarbeteende eller andra källor till osäkerhet, och erbjuder teoretiska garantier.

Project period

Number of project years

8

Calculated project time

2025-01-01 - 2032-12-31

Classifications

SCB-codes	10202. Information Systems (Social aspects to be 50804)
	10201. Computer Sciences

Keyword 1

Diversity algorithms

Keyword 2

Algorithmic fairness

Keyword 3

Recommender systems

Keyword 4

Approximation algorithms

Keyword 5

Planned use of research infrastructure

Planned use of research infrastructure

Yes

Research infrastructure/s

NAISS - National Academic Infrastructure for Supercomputing in Sweden

Other research infrastructure

Other applications or grants

Are any of the items relevant to you?

Yes

Justification and explanation of the relationship between the different projects and/or applications (English)

I currently have no ongoing grant from the Swedish Research Council.

I intend to apply for a project grant in the call closing on April 9, 2024. I understand that one can apply for these two grants simultaneously (distringuished professor grant and project grant), and choose one if both are funded.

The current proposal is related to my ongoing ERC Advanced Grant, titled "An algorithmic framework for reducing bias and polarization in online media (REBOUND)," which is funded from 2020 to 2026. The current proposal extends the ERC project significantly, in the following ways: (i) considering notions of diversity and fairness, while the ERC grant is focusing on polarization; (ii) aiming to study different types of information-access systems beyond social networks; (iii) incorporating user-behavior models and a variety of information-seeking actions; and (iv) planning to explore different types of computational approaches, such as, reinforcement learning and algorithms with predictions.

Ethical aspects: Legal and formal requirements

The research includes experiments on animals that requires ethical approval under the Animal Welfare Act (2018:1192)

No

The research includes studies on humans and/or biological material from humans and requires approval under the Act (2003:460) on ethical review of research relating to humans

No

The research includes the processing of personal data in accordance with the General Data Protection Regulation

Yes

Description of approvals and permits (English)

The research does not involve experiments on animals, nor studies involving humans.

The research involves handling of personal data, which will be used for the empirical evaluation of our methods, focusing on scalability measures and performance with respect to quality measures.

For evaluating our methods on real-world data, we will mainly use benchmark datasets that have been collected and/or curated by other research teams and have become publicly available to the research community. Such datasets are always anonymized and contain very minimal information for the problem at hand so that it is not possible to identify any individual.

Depending on the direction of our research, we may decide to collect our own datasets. If this is the case, we will strictly follow GDPR principles and best practices.
In particular:
* We will collect data that are already publicly available on the internet, e.g., reddit.
* We will be guided by the "data minimization principle," i.e., we will collect the minimal amount of data required for a specific research question that we want to study, and nothing more.
* We will make sure that the data are properly anonymized and securely stored.
* In our publications, we will never report data snippets, but we will only provide aggregate statistics on the performance of our methods.
* We will create an information notice at the project's website, to give information about the objectives and lawful basis of the research.

Ethical considerations

Description of ethical considerations (English)

In this project we will study methods for searching and exploring large amounts of data in modern information-access systems. Our aim is to go beyond identifying relevant content for individuals, and striving to maximize the diversity and fairness of the information presented to them. The indented use of these methods is to mitigate biases, promote a well-rounded understanding of topics, and avoid blind spots created by existing methods for filtering and prioritizing online content.

On the other hand, it is not uncommon that methods that have been designed for potentially beneficial use have unintentional and harmful consequences. As a concrete example, it could happen that, in an effort to present diverse and fair information to individuals, our methods will select content that falls into the fringes of what is considered socially acceptable, contain radical ideas, or untruths. In this particular example, however, we will claim that the unintentional abuse falls beyond the scope of our approach, since the presumed malign content is already present in the system, and individuals can reach to it via different routes. In other words, we believe that the unintentional abuse of our methods can be prevented by incorporating standard safeguard mechanisms to ensure the safety and legality of the available data, in addition to rigorous impact assessments and audits before and during deployment. Thus, we are confident that overall, our methods can contribute to the health of information-access systems.

Discussions and reflections on the ethical considerations for our methods will be held regularly with the project team members. We will also promote the culture of discussing ethical considerations in the reflection section of our research papers.

Sex and gender perspectives

Sex and gender perspectives in the proposed research

No

Motivate your answer (English)

This project does not involve sex and gender perspectives, as those described in the instructions provided by the Swedish Research Council. For example, we do not indent to analyze differences between women and men, nor do we indent to study how gender affiliations are created and understood.

It is worth noting that in the project we adopt an abstract view of diversity and fairness, and these notions can be defined with respect any any underlying attribute, or set of attributes, or even generic distance function. For example, when recommending movies to an individual, diversity could be defined with respect to the movie genre (comedy, drama, mystery, etc.), or with respect to the country of origin. On the other hand, naturally, diversity could also be defined with respect to gender-related attributes, e.g., the gender of the movie director. Our methods will be applicable to a broad range of cases, where diversity and fairness are defined appropriately for the intended application.

1. Research plan (English)

See following page for attachment

Research plan

Diversity and fairness in information-access systems (DIFIAS)

Aristides Gionis

1. Purpose and aims

In the modern information age we are submersed in a constant stream of data from various sources, ranging from the internet and social media to news outlets and podcasts. While this wealth of information has the potential to empower individuals, it also poses a significant challenge known as *information overload*: as the volume of available information continues to grow exponentially, individuals are increasingly struggling to sift through noisy data to find reliable, relevant, and meaningful content.

Mitigating the problem of information overload, in addition to cultivating mindful consumption habits, requires *technological solutions* tailored to the needs of individuals. Advanced *information-retrieval algorithms* can help streamline search processes, enabling users to find relevant content. *Recommender systems* play a crucial role by suggesting personalized content based on users' preferences and past interactions.

When designing smart tools for information access, ensuring *relevance* is paramount: users expect content that aligns closely to their interests and needs. Beyond relevance, however, *diversity* and *fairness* are equally crucial. Diversity ensures exposure to varied perspectives, while fairness ensures equitable access to information. Integrating diversity and fairness into information-access systems has numerous benefits, such as mitigating biases, helping counter filter-bubble and rabbit-hole effects, fostering a more inclusive and fair representation of different perspectives, and promoting a well-rounded understanding of topics.

While relevance, diversity, and fairness have been extensively studied in different areas in computer science, their interplay remains relatively understudied. We posit that incorporating diversity and fairness into modern information-access systems remains an unsolved problem, offering ample space for fundamental research contributions. The DIFIAS project aspires to address significant challenges in this area.

High-level goal of DIFIAS: We will develop theoretical foundations and novel abstractions to study notions of diversity and fairness in information-access systems. We will design algorithms for these problems with provable guarantees. Among different information-access systems we will focus on information-exploration systems, information networks, and two-sided information markets.

Objectives. Our overarching objective is to address deficiencies of modern information-access systems with regard to lack of diversity and unfair representation of content. To achieve this objective we aim to consolidate existing approaches, including our recent and ongoing work, and push the state-of-the-art by introducing novel abstractions, developing rigorous computational methods, and performing evaluations on real-world datasets. In particular, DIFIAS has the following research objectives.

Models and problems: Develop novel models and novel problem formulations that enable obtaining a deeper understanding on phenomena related to the lack of diversity and fairness in modern information-access systems. Focus on three specific domains: *information-exploration systems*, *information networks*, and *two-sided information markets*.

Algorithms: Develop computational methods for the models and problems that will be formulated. Our methods will be designed for different computational settings, e.g., combinatorial formulations, coping with stochastic and uncertain data, reinforcement learning, algorithms with predictions, and more. The proposed algorithms should be efficient and should offer theoretical guarantees.

Applications: Apply the developed methodology on different application scenarios and evaluate the resulting algorithms on real-world benchmark datasets. Implement the developed algorithms and make them available to the scientific community.

Research environment in KTH: Strengthen the area of algorithmic data analysis at the department of computer science in KTH and build an internationally prominent environment. Nurture doctoral students and postdoctoral researchers in the topic of the project, and create synergies with other faculty working on the foundations of data science, machine learning, and artificial intelligence. Strengthen and expand our international collaboration network.

Diversity vs. fairness. Diversity maximization and fairness assurance are both important considerations in machine learning. While they share some common goals, such as promoting inclusivity and reducing discrimination, they address different dimensions and require distinct methodologies and techniques.

Diversity maximization often relies on optimizing distance-based or coverage-based objectives, designed to ensure that the outputs generated by a system cover a wide range of perspectives. Diversity maximization is often applied in recommendation systems, search engines, and other decision-making systems. On the other hand, fairness aims to mitigate biases and ensure equitable treatment of individuals or groups. Fairness is often studied in contexts where decisions may impact individuals or groups differently, and finds applications in domains such as hiring, criminal justice, and healthcare.

In this project we consider that fairness concepts can be extended to other contexts, beyond individuals and demographic groups. For instance, we can talk about fairness in the context of a news recommender system, asking to ensure that a set of news articles represent fairly the political spectrum. In this way, similar to diversity, we can study fairness in the context of information-access systems. Furthermore, diversity and fairness are not substitute for one another, but they are complementary concepts.

2. State of the art

Maximizing diversity and promoting fairness have been studied extensively in different contexts in computer science, especially in recent times with the raising importance of *responsible AI* [15]. Due to space limitations we only discuss here some representative works and their connection with this proposal.

From the theoretical viewpoint, the literature mainly focuses on two notions of diversity: *coverage-based diversity*, relying on *submodular* coverage functions [4] and *pairwise dissimilarity-based* diversity, like *dispersion* [21]. Diversity has also been studied in *axiomatic* frameworks [19]. An appealing formulation is the *max-sum diversity* problem [5], which captures trade-offs between diversity and relevance. Solutions for max-sum diversity involve *combinatorial methods* [5] or *convex programming* [9], among other. Such formulations and techniques will form a basis for DIFIAS to study extensions and improved methods.

Diversity has also been studied in*information retrieval* and *recommender systems*, where it has been shown to improve user experience [7]. One classic method in information retrieval is the *maximal marginal relevance* (MMR) [6], while many other strategies seek to maximize some utility function that combines relevance and diversity [3, 25]. In this project, we aim to extend the state of the art by incorporating models of *user behavior*, investigating approaches based on *reinforcement learning* and *algorithms with predictions*, and studying novel notions for *fair representation* of recommended items.

Diversity and fairness in graph settings is significantly less-studied area, compared to item-selection and recommender-systems problems. Nonetheless, several ideas have been investigated, such as *adding* or *rewiring graph edges* for *reducing polarization* [2, 12, 20], *mitigating exposure to harmful content* [13, 18], or *improving fairness for the PageRank algorithm* [27]. Extending this line of work and introducing new models and methods for graph settings is a central goal of DIFIAS. In addition, while there is a growing amount of literature for recommendations in *two-sided information markets*, addressing also fairness issues [16, 28], the area is still not well explored and there is lack of a unified theory and established methods.

The topic of *bias and fairness in machine learning* has received a lot of interest in the recent years, having spawn a large community and dedicated dissemination venues, such as the FAccT conference. While many surveys and tutorials can be found online [8, 22], we note that our project is more closely related to notions of *bias and fairness in unsupervised machine learning*, such as *fair clustering* [11] and *fair graph mining* [17]. The PI, together with his team and research collaborators, have pioneered work on many of the above topics, including different formulations for *diversity in network analysis* [2, 12, 13, 24] *diversity in ranking problems* [30], as well as for *diversity-aware clustering* [26].

3. Significance and scientific novelty

Significance. Our project lies in the intersection of different subjects in computer-science: information retrieval, recommender systems, knowledge discovery, and algorithms design. While many of the themes have been studied previously in different contexts, in this project we will push forward the state of the art by studying diversity and fairness in new settings. Our methods will contribute to creating platforms that foster a more equitable and informed society, and mitigate the propagation of harmful biases online.

Scientific novelty. The project will make contributions in several different directions. First, we will design novel frameworks that model faithfully system entities and their interactions, while capturing notions of diversity and fairness and their inter-play with relevance. We will seek to establish a unified framework and common methodologies for studying diversity and fairness in the different settings. As it is common in fairness ML literature, we will rely on social-justice theories, such as distributive justice and equitable treatment of individuals, as well as in social-welfare objectives. In terms of methods, emphasis will be given to combinatorial algorithms, building on the previous work of the PI. In particular, we will consider techniques such as combinatorial optimization, optimization of submodular functions, local-search methods, greedy algorithms, semidefinite-programming relaxations, and convex optimization. Finally, we will investigate novel approaches based on reinforcement learning and algorithms with predictions [23].

4. Project description

4.1. Theory and methods

The project is structured along three *research themes*:

Exploration : diversity and fairness for information exploration tasks;
Networks : diversity and fairness in information networks; and
Information-Markets : diversity and fairness in information markets.

Each theme is characterized by a distinct type of an information-access system, having its own unique characteristics, so, different abstractions and methods will be applied. Connections among the themes do exist, and thus, we will seek to identify meaningful synergies.

Next we overview the three research themes of DIFIAS.

Research theme 1: Diversity and fairness for information-exploration tasks

We consider an information system that stores a large collection of content items. Users interact with the system and can access the items through various means, such as keyword searches, recommendations, or combinations of those. We assume that users have different interests, and the system has prior information about user interests and user behavior. Our setting will be general and it will model different scenarios, e.g., web-search engines, e-commerce systems, or platforms for browsing and reading news articles.

Our objective is to design methods that enable users to interact with the system and *explore the available information*. We are interested in designing methods that *enable users to discover new content items*, which are relevant to their interests, while satisfying criteria of diverse and fair information representation.

Most existing methods consider simplistic models for this problem; for instance, many works ask to *find a set of k items* that optimize some function that combines relevance and diversity. In the real world, however, information-exploration tasks are significantly more complex. First, items are presented to users in an order, and not as a set. Second, users may click on some of the presented item, initiating a new "round" of exploration. Third, users may terminate their interaction with the system at any point, based on the relevance and novelty of the information they have received and on the duration of their exploration session so far.

Motivated by these observations, we will introduce novel frameworks for information-exploration tasks that model *user behavior* and aim to maximize the total amount of knowledge accrued by the user during exploration, thus, combining relevance and diversity in a more intuitive way. In our preliminary work, we have studied a simple version of this problem where we ask to *maximize the expected diversity* of discovered content in the presence of the probability that a user may terminate exploration if they do not receive interesting content. Such a probability can be estimated from user–item relevance scores. The problem has interesting connections to the *ordered Hamiltonian-path problem*, and under mild assumptions we are able to design approximation algorithms with provable guarantees. In this project we aim to devise improved methods and extend our framework to more sophisticated user-behavior models. As a way to find optimal recommendation rankings in the presence of unknown user actions, we will also model user behavior in the setting of *algorithms with predictions* [23].

Another consideration in the information-exploration theme is to consider *fair representation of content* along different dimensions. As an example, when recommending news articles to a user, it is important to present more than one article from the same story, in order to ensure *coverage* of different sources with

respect to their *political leaning*, as well as with respect to their *stance* towards important entities in the stories. Additionally, we want to select stories that are well-align with user interests. This setting relates to the topic of *calibrated recommendations* [29]. In DIFIAS, we will develop methods for recommendations that offer *calibrated* as well as *fairly-represented* content. Furthermore, we will study problems that model the sequential-nature of recommendations [30].

Finally, we will study the information-exploration task using *reinforcement learning*. The idea would be to formulate the task as a bandit problem where the reward depends on actions performed in earlier steps, quantifying diversity and fairness considerations. The problem can be cast as a combinatorial multi-armed bandit [10], which will be the starting point for our research.

Research theme 2: Diversity and fairness in information networks

In the second research theme we will focus on information networks. As before, we consider a general setting, where networks may represent social networks, hyperlink graphs, or "recommendation networks" consisting of what-to-consume-next recommendations. We view networks as systems where information spreads and content is consumed by individuals. Information spread and content consumption is typically modeled via a dynamic process, such as random walks, shortest paths, local search, etc.

We additionally assume that network nodes are labeled according to certain attributes, e.g., demographic groups in a social network, or web page categories in a hyperlink graph. The interaction of network structure with node attributes typically gives rise to *network structural bias*. For example, contacts in a social network are more likely to have similar views on a topic, and thus, when navigating a network one may encounter biased information about the topic. The problem of mitigating structural bias in information networks is an emerging topic, and many recent papers have addressed related questions [1, 2, 12, 13, 18, 20]. Typical research questions are to identify network interventions, such as, edge additions, rewirings, or reweightings, to optimize given measures of bias or polarization.

In this project, we aim to advance the state of the art in in many different directions. First, many of the proposed techniques consider only two groups of nodes. Extending the existing methods for more than two groups, to account for realistic demographic scenarios or topics with multiple viewpoints, is a non trivial problem. Second, while many of the existing works consider the problems of minimizing bias and polarization, the issues of diversity and fairness in information networks have not been studied. We propose to study a novel measure of diversity with respect to random-walk navigation, defined as the *group cover time*, i.e., the expected time to visit at least one node from each group in a random walk starting from a given node. Our goal is to design network-intervention methods to optimize this diversity measure.

Additionally, while most methods consider random-walk navigation for information access, it is also interesting to study navigation models based on shortest-path distances. We recently studied the problem of minimizing the network diameter, while adding a small number of edges and respecting degree constraints [1]. We aim to extend this problem in settings with node attributes. The goal is to identify a small number of network interventions to optimize information access among different groups in the network.

In another direction, existing methods mainly consider *global interventions*, i.e., they seek to optimize a global network objective. It will be particularly interesting to study settings for *local interventions*, where we aim to provide *recourse actions* for a particular node in the network, in order to optimize diversity and fairness measures for that node. One challenge here is to ensure that such actions do not degrade the corresponding measures for other nodes in the network.

Finally, in all of the previous cases it is assumed that interventions are *deterministic*, e.g., edges can be added with probability 1. In many cases, interventions correspond to link recommendations, which are adopted with a certain probability (and often the adoption probability can be estimated). Thus, it will be interesting to study versions of those problems in the presence of *uncertainty* for the proposed interventions.

Research theme 3: Diversity and fairness in information markets

For the previous two research themes it is assumed that the content items are fixed and notions of diversity and fairness are pertinent exclusively to the information that users receive. On the other hand, in many cases, modern information-access systems are *two sided*, resembling *information markets*, where the users of the system are both *consumers* and *producers* of content. Examples of such systems include: music-sharing platforms, like Spotify; platforms used to facilitate physical-commodity markets, like renting apartments;

platforms used for advertising and seeking jobs, like LinkedIn; and other. In such an information-market system, consumers are interested in finding valuable content to satisfy their needs. On the other side, content producers aim to attract the attention of consumers by creating content that is valuable to the consumers. Both sides need to receive a sufficient amount of utility, otherwise they may leave the system.

It should be clear that, in addition to the respective relevance and attention objectives, there are important diversity and fairness considerations at play. From the side of consumers, content diversity is important to enrich their experience and fairness of representation is required so that they receive a well-balanced view of the available content. In addition, we would like to ensure that the system does not treat unfairly groups of users based on certain user attributes, e.g., gender or ethnicity. From the side of producers, fairness is paramount for ensuring that all producers have equal opportunities for their content to be visible to consumers, instead of, say, favoring only the most popular producers, or members of a protected group.

The topic of information search and content recommendations in two-sided information markets has recently received significant attention, and issues of fairness are of growing importance [16, 28]; one of the early papers was by the PI, albeit focusing on efficiency considerations [14]. Despite, we believe that the area is still not well explored, and there are not well-established concepts and methods.

In this project, we will seek to study novel abstractions that capture the interplay of consumer and producer diversity and fairness, and complement existing measures of relevance, attention, utility, and welfare economics in two-sided information markets. As in the previous research themes, we will incorporate models of user behavior in the system, study their effects to measures of interest, and design methods that produce recommendation sets, or ranked lists, that optimize such measures. We will also consider the fact that information markets are often hosted inside networking environments (e.g., LinkedIn is a social network serving as a job-market platform), and will leverage ideas from research theme #2 (Networks).

In addition, we will study dynamic aspects of diversity and fairness in information markets, as consumers and producers are likely to consume and produce a series of content within several sessions. Finally, in addition to considering the individual needs and utilities of the system actors separately, we will introduce notions of social welfare, and seek to understand the need for global social-good objectives. For example, diversity can play a role in ensuring a healthy level of information flow in the system and avoiding fragmentation the users into isolated communities.

4.2. Time plan and implementation

Time planning. The project will employ 3 doctoral students (PhD1, PhD2, PhD3) for 5 years each (working 80% in research and 20% as teaching assistants), and 3 postdocs (PostD1, PostD2, PostD3) for 2 years each. One postdoc will be funded by the WASP package of the PI. All other personnel will be funded by this VR grant. The timeline of the project with respect to research themes and personnel is as follows:

1. Exploration **:** PhD1 starting on year 1, PostD1 starting on year 2;
2. Networks **:** PhD2 starting on year 2, PostD2 starting on year 3;
3. Information-Markets **:** PhD3 starting on year 3, PostD3 starting on year 4;

The rationale for Exploration starting first is to study fundamental concepts that can be used in the other two themes. Information-Markets will start last, as it has the highest level of ambition, novelty, and risk. For each theme, the postdoc will start at the second year of the doctoral student, to be present and contribute to the most formative time of the student.

Research output. We will aim publishing our work at top-tier international venues, focus on quality rather than quantity. Target journals are IEEE TKDE, PVLDB, ACM TKDD, DMKD, etc. Target conferences are NeurIPS, ICML, SIGIR, SIGMOD, SIGKDD, WebConf, WSDM, etc.

Materials. Our publications will be available via open access in `arxiv.org`. The software and the other outputs of the project will become freely available to the scientific community via `github.com`.

Risks and mitigation. Devising efficient algorithms with provable quality guarantees is a challenging task and the largest risk of the project. Achieving this objective, however, offers the largest potential for scientific impact. If we are not able to prove theoretical results, we will study problems with simplifying assumptions, and will focus on devising heuristic methods and providing thorough empirical validation.

4.3. Project organization

The PI will devote 50% of his time in the project. He will supervise the doctoral students and postdocs, be responsible for scientific lead, and will allocate time to work on mathematical and algorithmic problems. He will be responsible for ensuring flow of information and collaborations with other groups in KTH and his international collaboration network, offering the possibility to the group to make research visits and internships. The PI is currently managing an ERC Advanced Grant (2020 to 2026), which also employs 3 doctoral students and 3 postdocs, so this will be a smooth transition to a similar-sized project.

We will encourage an environment of openness and collaboration, while ensuring that each team member leads their own project. During the hiring process we will support diversity and consider actions to achieve gender balance. Currently the PI supervises 6 doctoral students and the gender ratio is 3:3.

5. Need for research infrastructure

The project is mainly of theoretical nature and will not require extensive computing infrastructure. Commodity laptops will be provided to all team members. For implementing and evaluating our methods we will use the available KTH computing facilities and the National Academic Infrastructure for Supercomputing in Sweden (NAISS).

6. International and national collaboration

The PI has an extensive international collaboration network. Recent and on-going collaborations include prof. De Bie in Ghent University, prof. Terzi in Boston University, prof. Mannila in Aalto University, and Dr. Bonchi in Centai Labs. In spring 2024 the PI will spent one month as a visiting professor in Sapienza University of Rome, hosted by prof. Leonardi. In the near future the PI will apply for a sabbatical in Stanford University, planning to visit prof. Ugander. We will seek to strengthen and further expand this collaboration network. We will encourage the research team to be actively involved in national and international collaborations and make research visits and internships in other institutes.

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2. Research environment (English)

The project will employ 3 doctoral students for 5 years each (working 80% in research and 20% as teaching assistants, as it is typical in KTH), and 3 postdoctoral researchers for 2 years each. One postdoc will be funded by the WASP package of the PI, and all other personnel will be funded by this VR grant.

By the virtue of the WASP chair position of the PI, the doctoral students will join the WASP doctoral education network. They will benefit immensely from a unique environment that provides access to courses, events, connections with the industry, and networking with other doctoral students across Sweden. Similarly, the PI is an active faculty member in the Digital Futures research center, and all the team members will have opportunities to participate in the Digital Futures activities, including seminar series, workshops, opportunities for multi-disciplinary collaborations, and more.

With respect to project management, we will organize the team so that a pair of a doctoral student and a postdoc will work on the same research theme. In this way, we expect each postdoc to act as a mentor for a doctoral student, in addition to the postdoc pursuing their own research agenda. Furthermore, we will encourage collaborations among team members from different research themes, in order to bring synergies and allow for transfer of knowledge and expertise. We will however, ensure that each team member has a well-defined research project, with clear objectives to graduation (for the doctoral students) or to career development goals (for the postdocs). We will promote an environment of openness, and will pursue collaborations with other researchers who have expertise on important research areas for the project, either within KTH, or from abroad, taking advantage of our international network. We will encourage the members of the team to pursue research visits and internships abroad or attend international summer schools (subject of course to their personal preferences and constraints) and we will invite other researchers for visits and seminars at KTH.

The PI will devote 50% of his time in the project. The PI will supervise the doctoral students and postdocs, he will be responsible for scientific lead, and will allocate time to work on concrete mathematical and algorithmic problems. He will be responsible for ensuring rich flow of information and collaborations with other groups in KTH and the international collaboration network. He will be holding weekly one-to-one meetings with all the team members. In addition, the team will have weekly group meetings with varying agenda, ranging from brainstorming sessions to reporting progress on specific problems, and from dry-run presentations to journal clubs. The ERC Advanced Grant managed by the PI also employs 3 doctoral students and 3 postdocs, so we expect a smooth transition to a similar-sized project.

During the hiring process we will support diversity and consider actions to achieve gender balance, which we believe will promote the overall gender balance in the department. Currently the PI supervises 6 doctoral students and the gender ratio is 3:3. In addition, there are currently 5 postdocs in the team and the gender ratio is 2(female):3(male).

3. Added value (English)

While Sweden has a strong tradition in many areas of machine learning and AI, we believe that there is potential for further growth in the area of algorithmic data analysis and foundations of data science. This project can act as a catalyst in consolidating this research area and building a strong internationally-prominent environment in KTH. The division of Theoretical Computer Science, with many faculty members working on the broad area of data science and having strong interest in foundational research, is ideally situated to be the host institution of the project.

The PI is a WASP professor in KTH, with strong track record, excellent international reputation, and he is currently managing a successful ERC Advanced Grant. All these factors will help attracting high-achieving doctoral students and other exceptional researchers. Furthermore, the department is currently planning to recruit another assistant professor specializing in algorithms and data analysis, also funded by WASP. We expect this hire to bring significant added value to the project and further strengthen the research environment. In particular, we anticipate many joint projects and many opportunities for co-supervision with the new assistant professor. We also envision collaboration and opportunities for co-supervision with a new assistant professor in the division (Ioanna Bercea) who is working on algorithms and data structures. As a concrete area for initial discussions and collaboration with prof. Bercea we have identified the topic of algorithms with predictions in the first research theme. Prof. Bercea is also an author of a well-cited paper on fair data clustering, which has strong connections with the topic of this project.

It should also be noted that the added value of the environment will be further enhanced by allocating 1 postdoc from the WASP funding package of the PI to this project.

Overall, we expect that the various opportunities for collaboration with researchers outside the project and the integration with already established environments in KTH and WASP will bring significant benefits, both in the near and distant future. In the short term, we expect that the vibrant environment will foster fresh ideas and will enable significant research results. In the long term, we aspire that building a strong team will attract more highly-accomplished researchers and additional funding resources, to ensure sustained growth and prominence.

Research leadership

Research leadership (English)

See following page for attachment

Research leadership

Diversity and fairness in information-access systems (DIFIAS)

Aristides Gionis

1. Research topics and track record

My work on data science spans a career of over 20 years, which includes numerous contributions in algorithmic data-analysis research, and consolidates experience from academia and industry. I have been in academia since 2013 (2013 to 2019 in Aalto University and 2020 to present in KTH). Prior to that I was a senior research scientist in Yahoo! Research Labs.

The main focus of my work has been in data mining and algorithmic data analysis. My approach and philosophy to research is driven by considering practical problems motivated by real-world application scenarios, and then abstracting the problems to simpler mathematical formulations and developing novel and theoretically-rigorous solutions.

Over the years I have published over 60 journal and over 170 conference publications, in peer-reviewed top-tier international journals and conferences. Many of my publications have attracted significant attention in the community and have generated a volume of follow-up works. The areas that I have made significant contributions and have published highly-cited papers include the following:

- similarity search in high dimensional spaces;
- significance testing for data mining results;
- graph mining: efficient computation of graph motifs, discovery of dense subgraphs, community detection, role mining, network inference, etc.;
- social-network and social-media analysis;
- analysis of temporal networks and information-diffusion in networks;
- analysis of urban data;
- data clustering;
- interpretable models for machine learning.

My publications have received *1 test-of-time award*, *4 best-paper awards*, and *4 best-student paper awards*, co-authored by students under my supervision.

2. Research supervision

I am proud of the doctoral students and postdocs that I have supervised over the years. I want to believe that I have inspired them by being example for hard work, hands-on style of research, high standards of quality and academic integrity, and always treating them as peers.
In Aalto I have supervised (as main supervisor) 10 doctoral students and 8 postdocs, all graduated.
In KTH I have supervised (as main supervisor) 1 doctoral student and 2 postdocs, all graduated.
Currently, in KTH I am supervising (as main supervisor) 6 doctoral students and 5 postdocs.
Some examples of the current positions of the doctoral students and postdocs that I have supervised are the following:

- Eric Malmi, PhD student, 2018,[1] Google.
- Sanja Scepanovic, PhD student, 2018, Bell Labs.
- Kiran Garimella, PhD student, 2018, assistant professor in Rutgers University.
- Polina Rozenshtein, PhD student, 2019, Amazon.
- Suhas Thejaswi, PhD student, 2022, postdoc in MPI.
- Nikolaj Tatti, postdoc, 2017, associate professor in the University of Helsinki.
- Michael Mathioudakis, postdoc, 2017, associate professor in the University of Helsinki.
- Stefan Neumann, postdoc, 2023, assistant professor in TU Vienna.

[1] The year graduation year.

3. International recognition

My recognition from the international research community is reflected in my participation in the editorial board of two high-impact journals: ACM Transaction on the Web (TWEB), and Data Mining and Knowledge Discovery (DMKD). I have consistently participated as a senior PC member or area chair in most major conferences in data discovery and knowledge management in the last 10, or more, years. Additionally, I have been a program co-chair of the following conferences: ECML PKDD 2010, ACM WSDM 2013, the Web Conference 2022, and ACM WSDM 2024.

I have been invited for seminars and keynote presentations in many occasions, including the European Conference on Machine Learning and Data Mining, the Conference on Complex Networks, the Austrian Computer Science Day, the distinguished lecture series in EPFL, and numerous international workshops and symposiums.

Finally, I have been an examiner in 30 PhD dissertation committees.

Description of merits

Description of merits (English)

The qualification that better reflects the potential to implement successfully the proposed research, in my view, is my extensive publication record and emphasis on high-quality research outputs. I believe that this demonstrates best my ability to select important research topics to work on, my depth of knowledge in computational methods, and my aptitude to pursue sound and rigorous approaches.

Second, I have extensive expertise on managing large research projects, including four projects from the Academy of Finland, two European Research-and-Infrastructure projects, my ERC Advanced Grant, and the funding provided via my WASP chair position. I believe that this experience has equipped me with the necessary skills to recruit high-achieving doctoral students and postdocs, and to inspire and motivate them to reach the best of their potential and achieve their goals.

Last, I am very actively engaged in the endeavors of my scientific community, as an editorial-board member in high-impact journals, as well as PC member and PC co-chair in major events. I pursue collaborations with my international network, and I travel for research visits, conferences, and invited seminars. I believe that such active participation will benefit the members of my team by exposing them to the latest research ideas and giving them diverse perspectives. It will also provide networking opportunities and will inspire academic and professional growth.

Publications and other research outputs

Publications and other research outputs

See following page for attachment

Publications and other research outputs

Diversity and fairness in information-access systems (DIFIAS)

Aristides Gionis

March, 2024

1 Selection of research outputs

We list 10 recent publications that are the most relevant for the proposed research project.

1. L. Oettershagen, H. Wang, **A. Gionis**, *"Finding densest subgraphs with edge-color constraints"*, to appear in the ACM Web Conference (WebConf) 2024

   We study a variant of the *densest subgraph problem*, where we consider constraints on the types of edges in the solution subgraph. Such constraints can be seen as *diversity* or *fairness* constraints. The PI contributed to the conception of the idea, design of methods, mathematical proofs, supervision of doctoral students and postdocs, and paper writing.

2. T. Zhou, S. Neumann, K. Garimella, **A. Gionis**, *"Modeling the impact of timeline algorithms on opinion dynamics using low-rank updates"*, to appear in the ACM Web Conference (WebConf) 2024

   We study the problem of making small modifications in the timeline of users in social media in order to minimize the *polarization and disagreement* in the network, which are quantified using the *Friedkin–Johnsen opinion-formation model*. The PI contributed to the conception of the idea, design of methods, supervision of doctoral students and postdocs, and paper writing.

3. F. Adriaens, H. Wang, **A. Gionis**, *"Minimizing hitting time between disparate groups with shortcut edges"*, 29th International Conference on Knowledge Discovery and Data Mining (KDD) 2023

   We study the problem of adding a small number of shortcut edges in a network to minimize the *average hitting time* and the *maximum hitting time* between two groups in the network, and thus, minimizing the network *structural bias*. The PI contributed to the conception of the idea, design of methods, mathematical proofs, supervision of doctoral students and postdocs, and paper writing.

4. C. Coupette, S. Neumann, **A. Gionis**, *"Reducing exposure to harmful content via graph rewiring"*, 29th International Conference on Knowledge Discovery and Data Mining (KDD) 2023

   We consider networks where content items are connected via recommendations, and we assume that a subset of nodes contain "harmful" content. We then study the problem of *reducing the exposure to harmful content* via *edge rewirings*. The PI contributed to the conception of the idea, design of methods, mathematical proofs, supervision of doctoral students and postdocs, and paper writing.

5. B. Ordozgoiti, A. Mahadevan, A. Matakos, **A. Gionis**, *"Provable randomized rounding for minimum-similarity diversification"*, Data Mining and Knowledge Discovery (DMKD), vol. 36, num. 2, 2022

   We design provable methods for *diversifying items* when diversity is measured using *similarity functions*, as opposed to numerous previous works that consider distance functions. The PI contributed to the conception of the idea, design of methods, mathematical proofs, supervision of doctoral students and postdocs, and paper writing.

6. G. Zhang, N. Tatti, **A. Gionis**, *"Ranking with submodular functions on a budget"*, Data Mining and Knowledge Discovery (DMKD), vol. 36, num. 3, 2022

   We introduce a new setting that can be used to introduce *diversity for ranked lists of items*, where previous works mainly define diversity only over sets of items. We refer to this new problem as *max-submodular ranking* (MSR). The PI contributed to the conception of the idea, design of methods, supervision of doctoral students and postdocs, and paper writing.

7. A. Matakos, C. Aslay, E. Galbrun, **A. Gionis**, *"Maximizing the diversity of exposure in a social network"*, IEEE Transactions Knowledge Data Engineering (TKDE), vol. 34, num. 9, 2022

   We study the problem of recommending a small number of news articles to selected users to *maximize the diversity of exposure* in a social network. We consider a setting where *information spreads* through network nodes. The PI contributed to the conception of the idea, design of methods, mathematical proofs, supervision of doctoral students and postdocs, and paper writing.

8. F. Adriaens, **A. Gionis**, *"Diameter minimization by shortcutting with degree constraints"*, 22nd International Conference on Data Mining (ICDM) 2022

   We study the problem of adding a fixed number of edges to undirected graph to *minimize its diameter*, under the constraint that the number of edges added to each vertex is bounded. The PI contributed to the conception of the idea, design of methods, mathematical proofs, supervision of doctoral students and postdocs, and paper writing.

9. S. Thejaswi, B. Ordozgoiti, **A. Gionis**, *"Diversity-aware k-median: clustering with fair center representation"*, European Conference on Machine Learning and Principles and Practice of Knowledge Discovery (ECML PKDD) 2021

   We introduce a novel problem for *diversity-aware clustering* with *fair center representation*. We assume that cluster centers belong to different groups, and we ask to find a minimum-cost clustering so that a minimum number of cluster centers are chosen from each group. The PI contributed to the conception of the idea, design of methods, mathematical proofs, supervision of doctoral students and postdocs, and paper writing.

10. S. Tu, C. Aslay, **A. Gionis**, *"Co-exposure maximization in online social networks"*, Conference on Neural Information Processing Systems (NeurIPS) 2020

    We study the problem of allocating seed users to two opposing campaigns with the aim to *maximize the expected number of users who are co-exposed to both campaigns*. We consider a setting where *information spreads* through network nodes. The PI contributed to the conception of the idea, design of methods, mathematical proofs, supervision of doctoral students and postdocs, and paper writing.

2 Relevant peer-reviewed research outputs from 2016 to 2024

2.1 Journal articles

- G. Zhang, **A. Gionis**, *"Regularized impurity reduction: Accurate decision trees with complexity guarantees"*, Data Mining and Knowledge Discovery (DMKD), volume 37, number 1, 2023
- M. Ciaperoni, H. Xiao, **A. Gionis**, *"Concise and interpretable multi-label rule sets"*, Knowledge and Information Systems (KAIS), volume 65, number 12, 2023
- A. Matakos, **A. Gionis**, *"Strengthening ties towards a highly-connected world"*, Data Mining and Knowledge Discovery (DMKD), volume 36, number 1, 2022
- B. Ordozgoiti, A. Mahadevan, A. Matakos, **A. Gionis**, *"Provable randomized rounding for minimum-similarity diversification"*, Data Mining and Knowledge Discovery (DMKD), volume 36, number 2, 2022
- G. Zhang, N. Tatti, **A. Gionis**, *"Ranking with submodular functions on a budget"*, Data Mining and Knowledge Discovery (DMKD), volume 36, number 3, 2022
- A. Merchant, **A. Gionis**, M. Mathioudakis, *"Succinct graph representations as distance oracles: an experimental evaluation"*, Proceedings of the VLDB Endowment (PVLDB), volume 15, number 11, 2022
- A. Matakos, C. Aslay, E. Galbrun, **A. Gionis**, *"Maximizing the diversity of exposure in a social network"*, IEEE Transactions Knowledge Data Engineering (TKDE), volume 34, number 9, 2022
- P. Rozenshtein, N. Tatti, **A. Gionis**, *"The network-untangling problem: from interactions to activity timelines"*, Data Mining and Knowledge Discovery (DMKD), volume 35, number 1, 2021

- S. Thejaswi, **A. Gionis**, J. Lauri, *"Finding path motifs in large temporal graphs using algebraic fingerprints"*, Big Data, volume 8, number 5, 2020
- F. Adriaens, T. De Bie, **A. Gionis**, J. Lijffijt, A. Matakos, P. Rozenshtein, *"Relaxing the strong triadic closure problem for edge strength inference"*, Data Mining and Knowledge Discovery (DMKD), volume 34, number 3, 2020
- A. Matakos, S. Tu, **A. Gionis**, *"Tell me something my friends do not know: diversity maximization in social networks"*, Knowledge and Information Systems (KAIS), volume 62, number 9, 2020
- I. Karlsson, J. Rebane, P. Papapetrou, and **A. Gionis**, *"Locally and globally explainable time-series tweaking"*, Knowledge and Information Systems (KAIS), volume 62, number 5, 2020
- K. Garimella, G. De Francisci Morales, **A. Gionis**, and M. Mathioudakis, *"Quantifying controversy on social media"*, ACM Transactions on Social Computing (TSC), volume 1, issue 1, 2018
- O. Kostakis, N. Tatti, and **A. Gionis**, *"Discovering recurring activity in temporal networks"*, Data Mining and Knowledge Discovery (DMKD), volume 31, number 6, 2017
- E. Malmi, S. Chawla, **A. Gionis**, *"Lagrangian relaxations for multiple network alignment"*, Data Mining and Knowledge Discovery (DMKD), volume 31, number 5, 2017
- P. Rozenshtein, N. Tatti, and **A. Gionis**, *"Finding dynamic dense subgraphs"*, ACM Transactions on Knowledge and Data Discovery (TKDD), volume 29, number 3, 2017
- **A. Gionis**, M. Mathioudakis, A. Ukkonen, *"Bump hunting in the dark: Local discrepancy maximization on graphs"*, IEEE Transactions of Knowledge Engineering (TKDE), volume 29, number 3, 2017
- E. Galbrun, **A. Gionis**, N. Tatti, *"Top-k overlapping densest subgraphs"*, Journal of Data Mining and Knowledge Discovery (DMKD), volume 30, issue 5, 2016
- G. De Francisci Morales, **A. Gionis**, *"Streaming similarity self-join"*, Proceedings of Very Large Databases (PVLDB), volume 9, number 10, 2016

2.2 Conference articles

- L. Oettershagen, H. Wang, **A. Gionis**, *"Finding densest subgraphs with edge-color constraints"*, to appear in the ACM Web Conference (WebConf) 2024
- T. Zhou, S. Neumann, K. Garimella, **A. Gionis**, *"Modeling the impact of timeline algorithms on opinion dynamics using low-rank updates"*, to appear in the ACM Web Conference (WebConf) 2024
- F. Cinus, **A. Gionis**, F. Bonchi, *Rebalancing social feed to minimize polarization and disagreement"*, ACM International Conference on Information and Knowledge Management (CIKM) 2023
- J. Spoerhase, K. Khodamoradi, B. Riegel, B. Ordozgoiti, **A. Gionis**, *"A constant-factor approximation algorithm for reconciliation k-median"*, 26th International Conference on Artificial Intelligence and Statistics (AISTATS) 2023
- F. Adriaens, H. Wang, **A. Gionis**, *"Minimizing hitting time between disparate groups with shortcut edges"*, 29th International Conference on Knowledge Discovery and Data Mining (KDD) 2023
- C. Coupette, S. Neumann, **A. Gionis**, *"Reducing exposure to harmful content via graph rewiring"*, 29th International Conference on Knowledge Discovery and Data Mining (KDD) 2023
- S. Tu, S. Neumann, **A. Gionis**, *"Adversaries with limited information in the Friedkin-Johnsen model"*, 29th International Conference on Knowledge Discovery and Data Mining (KDD) 2023
- G. Zhang, N. Tatti, **A. Gionis**, *"Finding favourite tuples on data streams with provably few comparisons"*, 29th International Conference on Knowledge Discovery and Data Mining (KDD) 2023
- R.C. Tzeng, P.A. Wang, F. Adriaens, **A. Gionis**, C.J. Lu, *"Improved analysis of randomized SVD for top-eigenvector approximation"*, 22th International Conference on Artificial Intelligence and Statistics (AISTATS) 2022

- M. Ciaperoni, C. Aslay, **A. Gionis**, M. Mathioudakis, *"Workload-aware materialization of junction trees"*, 25th International Conference on Extending Database Technology (EDBT) 2022
- G. Zhang, N. Tatti, **A. Gionis**, *"Coresets remembered and items forgotten: submodular maximization with deletions"*, 22nd International Conference on Data Mining (ICDM) 2022
- F. Adriaens, **A. Gionis**, *"Diameter minimization by shortcutting with degree constraints"*, 22nd International Conference on Data Mining (ICDM) 2022
- B. Ordozgoiti, A. Matakos, **A. Gionis**, *"Generalized leverage scores: geometric interpretation and applications"*, 39th International Conference on Machine Learning (ICML) 2022
- M. Ciaperoni, **A. Gionis**, A. Katsamanis, P. Karras, *"SIEVE: A space-efficient algorithm for Viterbi decoding"*, Proceedings of the 2022 International Conference on Management of Data (SIGMOD) 2022
- A. Anagnostopoulos, **A. Gionis**, N. Parotsidis, *"Collaborative procrastination"*, 11th International Conference on Fun with Algorithms (FUN) 2021
- C. Aslay, M. Ciaperoni, **A. Gionis**, M. Mathioudakis, *"Workload-aware materialization for efficient variable elimination on Bayesian networks"*, 37th IEEE International Conference on Data Engineering (ICDE) 2021
- S. Thejaswi, B. Ordozgoiti, **A. Gionis**, *"Diversity-aware k-median: Clustering with fair center representation"*, European Conference on Machine Learning and Principles and Practice of Knowledge Discovery (ECML PKDD) 2021
- G. Zhang, **A. Gionis**, *"Diverse rule sets"*, 26th International Conference on Knowledge Discovery and Data Mining (KDD) 2020
- T. Lanciano, F. Bonchi, **A. Gionis**, *"Explainable classification of brain networks via contrast subgraphs"*, 26th International Conference on Knowledge Discovery and Data Mining (KDD) 2020
- S. Tu, C. Aslay, **A. Gionis**, *"Co-exposure maximization in online social networks"*, Conference on Neural Information Processing Systems (NeurIPS) 2020
- R.C. Tzeng, B. Ordozgoiti, **A. Gionis**, *"Discovering conflicting groups in signed networks"*, Conference on Neural Information Processing Systems (NeurIPS) 2020
- S. Thejaswi, **A. Gionis**, *"Pattern detection in large temporal graphs using algebraic fingerprints"*, SIAM International Conference on Data Mining (SDM) 2020
- R. Matsuno, **A. Gionis**, *"Improved mixing time for k-subgraph sampling"*, SIAM International Conference on Data Mining (SDM) 2020
- G. Zhang, **A. Gionis**, *"Maximizing diversity over clustered data"*, SIAM International Conference on Data Mining (SDM) 2020
- H. Xiao, B. Ordozgoiti, **A. Gionis**, *"Searching for polarization in signed graphs: a local spectral approach"*, ACM Web Conference (WebConf) 2020
- B. Ordozgoiti, A. Matakos, **A. Gionis**, *"Finding large balanced subgraphs in signed networks"*, ACM Web Conference (WebConf) 2020
- F. Bonchi, E. Galimberti, **A. Gionis**, B. Ordozgoiti, G. Ruffo, *"Discovering polarized communities in signed networks"*, ACM International Conference on Information and Knowledge Management (CIKM) 2019
- F. Adriaens, C. Aslay, T. De Bie, **A. Gionis**, J. Lijffijt, *"Discovering interesting cycles in directed graphs"*, ACM International Conference on Information and Knowledge Management (CIKM) 2019
- B. Ordozgoiti, **A. Gionis** *"Reconciliation k-median: Clustering with non-polarized representatives"*, ACM Web Conference (WebConf) 2019
- H. Xiao, C. Aslay, and **A. Gionis**, *"Robust cascade reconstruction by Steiner tree sampling"*, 18th International Conference on Data Mining (ICDM) 2018
- F. Adriaens, T. De Bie, **A. Gionis**, J. Lijffijt, and P. Rozenshtein, *"From acquaintance to best friend forever:*

robust and fine-grained inference of social-tie strengths", International Workshop of Machine Learning with Graphs (MLG) 2018

- E. Malmi, A. Solin, and **A. Gionis**, *"Computationally inferred genealogical networks uncover long-term trends in assortative mating"*, 27th International World Wide Web Conference (WWW) 2018
- K. Garimella, G. De Francisci Morales, **A. Gionis**, and M. Mathioudakis, *"Political discourse on social media: Echo chambers, gatekeepers, and the price of bipartisanship"*, 27th International World Wide Web Conference (WWW) 2018
- H. Xiao, P. Rozenshtein, N. Tatti, and **A. Gionis**, *"Reconstructing a cascade from temporal observations"*, SIAM International Conference on Data Mining (SDM) 2018
- P. Lahoti, K. Garimella, **A. Gionis**, *"Joint non-negative matrix factorization for learning ideological leaning on twitter"*, 11th International Web Search and Data Mining Conference (WSDM) 2018
- K. Garimella, **A. Gionis**, N. Parotsidis, and N. Tatti, *"Balancing information exposure in social networks"*, Conference on Neural Information Processing Systems (NeurIPS) 2017
- E. Malmi, **A. Gionis**, E. Terzi, *"Active network alignment: a matching-based approach"*, ACM International Conference on Information and Knowledge Management (CIKM) 2017
- P. Rozenshtein, N. Tatti, **A. Gionis**, *"Inferring the strength of social ties: a community-driven approach"*, ACM Conference on Knowledge Discovery and Data Mining (KDD) 2017
- K. Garimella, G. De Francisci Morales, **A. Gionis**, M. Mathioudakis, *"The ebb and flow of controversial debates on social media"*, 11th International Conference on Web and Social Media (ICWSM) 2017
- K. Garimella, G. De Francisci Morales, **A. Gionis**, M. Mathioudakis, *"Exposing twitter users to contrarian news"*, 26th International World Wide Web Conference (WWW) 2017 (demo)
- E. Malmi, M. Rasa, **A. Gionis**, *"AncestryAI: A Tool for exploring computationally inferred family trees"*, 26th International World Wide Web Conference (WWW) 2017 (demo)
- **A. Gionis**, P. Rozenshtein, N. Tatti, and E. Terzi, *"Community-aware network sparsification"*, SIAM International Conference on Data Mining (SDM) 2017
- K. Garimella, G. De Francisci Morales, **A. Gionis**, and M. Mathioudakis, *"Reducing controversy by connecting opposing views"*, 10th International Web Search and Data Mining Conference (WSDM) 2017
- M. Arockiasamy, N. Tatti, and **A. Gionis**, *"A combinatorial approach to role discovery"*, 16th International Conference on Data Mining (ICDM) 2016
- P. Rozenshtein and **A. Gionis**, *"Temporal PageRank"*, European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECML PKDD) 2016
- P. Rozenshtein, **A. Gionis**, B.A. Prakash, J. Vreeken, *"Reconstructing an epidemic over time"*, 22nd International Conference on Knowledge Discovery and Data Mining (KDD) 2016
- E. Malmi, P. Takala, H. Toivonen, T. Raiko, **A. Gionis**, *"DopeLearning: A computational approach to rap lyrics generation"*, 22nd International Conference on Knowledge Discovery and Data Mining (KDD) 2016

2.3 Edited volumes

- F. Laforest, R. Troncy, E. Simperl, D. Agarwal, **A. Gionis**, I. Herman, L. Médini, *"Companion of The Web Conference 2022"*, Virtual Event, Lyon, France, April 25–29, 2022
- I. Assent, C. Domeniconi, **A. Gionis**, E. Hüllermeier, *"Introduction to the special issue of the ECML PKDD 2020 journal track"*, Machine Learning 2020

Letter of Support

Letter of support (English)

See following page for attachment

To:
Vetenskapsrådet
Västra Järnvägsgatan 3
Box 1035, SE-101 38 Stockholm

Application to distinguished professor grant within natural and engineering sciences 2024

Letter of support for Prof. Aristides Gionis

I am writing to express my enthusiastic support for the application of Prof. Aristides Gionis for a VR distinguished professor grant within natural and engineering sciences 2024. As Head of the Department of Computer Science in KTH, I have great confidence in Prof. Gionis' research expertise and dedication to excellence.

Prof. Gionis has extensive experience in managing large research projects through his ERC Advanced Grant and his KTH WASP chair position. Supported by these projects, he has built a highly-successful research team in the area of algorithms and data analysis, comprising of several doctoral students and postdocs.

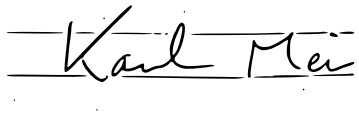
KTH's goal is to further strengthen this research area and build an internationally renowned environment, focusing on the foundations of data science, machine learning, and artificial intelligence. Several of our existing faculty members contribute actively to this broad area. Notably, we have recently appointed a female assistant professor specializing in algorithms and complexity (Bercea), and we are presently engaged in the recruitment of another assistant professor specializing in algorithms and data analysis. This recruitment effort is supported in part by Prof. Gionis' WASP funding package. The VR distinguished professor project would allow us to advance these objectives by offering internationally competitive resources to attract exceptional talent across various academic tiers.

The KTH CS department is committed to supporting Prof. Gionis throughout the duration of the VR distinguished professor research project. We will provide necessary resources, including facilities, equipment, and administrative assistance. Furthermore, we will actively facilitate additional funding applications and foster collaborations within networks to enrich the project's outcomes. We are excited about the prospect of contributing to the establishment and build-up of an environment conducive to groundbreaking research.

KTH is Sweden's largest technical university with strong research in many areas and has always demonstrated strong leadership in pushing technologies forward for the benefit of mankind. KTH strives to maintain its strong and vital role in the future of Swedish and European research, education, and its impact on society at large. This requires a strong foundation of competence and knowledge that is based on excellence in engineering and the sciences.

KTH supports the application within the distinguished professor grant to VR by Prof. Aristides Gionis, and ensures that he will have all the local support needed in order to realize his vision described in the proposal.

Yours sincerely,



Karl Meinke, Professor
Head of the Department of Computer Science, School of Electrical Engineering and Computer Science, KTH

Activity level in the project

Activity level in the project

Role in the project	Name	Percent of full time
1 Applicant	Aristides Gionis	50%

Applied amount

Standard amount

Standard amount	2025	2026	2027	2028	2029
StandardAmount	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000

2030	2031	2032	Total
4,000,000	4,000,000	4,000,000	32,000,000

Justification of the budget applied for

Justification of the budget applied for (English)

In total, we plan to recruit 3 PhD students for 5 years each, at 80% research activity, and 3 postdocs for 2 years each, at 100% research activity. All doctoral students and postdocs will be recruited as KTH employees. The PI will allocate 50% of his time in the project.

The VR grant will cover the costs of the PI's 50% time, the 3 doctoral students, and the 2 postdocs.

The 3rd postdoc will be funded by the WASP funding package of the PI.

The break down of the project costs is as follows:

PI 50% time for 8 years, including KTH overheads and premises: 14,018 ksek
2 postdocs 100% time, 2 years each, including KTH overheads and premises: 5,156 ksek
3 PhD students 80% time, 5 years each, including KTH overheads and premises: 11,946 ksek
Travel for the whole team, 100 ksek per year, for 8 years: 800 ksek
Other direct costs, 10 ksek per year: 80 ksek

Total: 32 million sek

Other funding

Other funding for this project

Funder	Applicant/project leader	Type of grant	Status	Reg no or equiv.
1 WASP	Gionis	Professorship funding	Granted	0
Total				

	2025	2026	2027	2028	2029	2030
1	0	1,289,000	1,289,000	0	0	0
Total	0	1,289,000	1,289,000	0	0	0

	2031	2032	Total
1	0	0	2,578,000
Total	0	0	2,578,000

CV

CV - Aristides Gionis

Project leader: Aristides Gionis
Birthdate: 19720926
Gender: Male
Country: Sweden
Doctoral degree: 2003-07-02
Academic title: Professor
Employer: Kungliga Tekniska högskolan

Doctors degree

Examination	Organisation	Dissertation title (original language)	Supervisor
10201. Computer Sciences, 2003-07-02	Stanford University, Department of Computer Science	Algorithms for similarity search and clustering in large data sets	Rajeev Motwani

Educational history

Research education

Examination	Organisation	Dissertation title	Name of supervisor
PhD degree, 10201. Computer Sciences, 2003-07-02	Stanford University, United States, Department of Computer Science	Algorithms for similarity search and clustering in large data sets	Rajeev Motwani

Basic education

Year	Examination
1998	10201. Computer Sciences, Degree of master (120 credits), Stanford University, United States
1994	10202. Information Systems (Social aspects to be 50804), Degree of Bachelor, National and Kapodistrian University of Athens, Greece

Professional history

Employments

Period	Position	Part of research in employment	Employer
januari 2020 - Present	Professor, Permanent employment	100	KTH Royal Institute of Technology, Sweden, CS - Theoretical Computer Science
januari 2020 - december 2024	Adjunct professor, Temporary position	20	Aalto University, Finland, School of Science
juli 2017 - december 2019	Professor, Permanent employment	100	Aalto University, Finland, School of Science
januari 2013 - juni 2017	Associate professor, Permanent employment	100	Aalto University, Finland, School of Science

Period	Position	Part of research in employment	Employer
september 2006 - december 2012	Senior research scientist, Permanent employment	100	Yahoo!, Spain, Yahoo! Research Labs

Post doctoral assignments

Period	Organisation	Subject
augusti 2003 - augusti 2006	University of Helsinki, Finland	10201. Computer Sciences

Research exchange assignments

Period	Type	Organisation	Subject
april 2024 - april 2024	Visiting professor	Sapienza University of Rome, Italy, Department of Computer, Control, and Management Engineering	10206. Computer Engineering
oktober 2017 - oktober 2017	Visiting professor	Sapienza University of Rome, Italy, Department of Computer, Control, and Management Engineering	10206. Computer Engineering

Merits and awards

Supervised persons

Year	Supervised persons	University (supervisee)	Role
2024	PhD student, Martino Ciaperoni	Aalto University, Finland, School of Science	Main supervisor
2023	PhD student, Guangyi Zhang	KTH Royal Institute of Technology, Sweden, CS - Teoretisk datalogi	Main supervisor
2022	PhD student, Antonis Matakos	Aalto University, Finland, School of Science	Main supervisor
2022	PhD student, Suhas Thejaswi	Aalto University, Finland, School of Science	Main supervisor
2020	PhD student, Han Xiao	Aalto University, Finland, School of Science	Main supervisor
2018	PhD student, Eric Malmi	Aalto University, Finland, School of Science	Main supervisor
2018	PhD student, Kiran Garimella	Aalto University, Finland, School of Science	Main supervisor
2018	PhD student, Polina Rozenshtein	Aalto University, Finland, School of Science	Main supervisor
2018	PhD student, Sanja Scepanovic	Aalto University, Finland, School of Science	Main supervisor
2017	PhD student, Orestis Kostakis	Aalto University, Finland, School of Science	Main supervisor
2023	Postdoc, Stefan Neumann	KTH Royal Institute of Technology, Sweden, CS - Teoretisk datalogi	Main supervisor
2022	Postdoc, Florian Adriaens	KTH Royal Institute of Technology, Sweden, CS - Teoretisk datalogi	Main supervisor
2021	Postdoc, Bruno Ordozgoiti	Aalto University, Finland, School of Science	Main supervisor

Year	Supervised persons	University (supervisee)	Role
2021	Postdoc, Cigdem Aslay	Aalto University, Finland, School of Science	Main supervisor
2019	Postdoc, Polina Rozenshtein	Aalto University, Finland, School of Science	Main supervisor
2018	Postdoc, Esther Galbrun	Aalto University, Finland, School of Science	Main supervisor
2017	Postdoc, Fabio Vitale	Aalto University, Finland, School of Science	Main supervisor
2017	Postdoc, Michael Mathioudakis	Aalto University, Finland, School of Science	Main supervisor
2017	Postdoc, Nikolaj Tatti	Aalto University, Finland, School of Science	Main supervisor
2015	Postdoc, Gianmarco De Francisci Morales	Aalto University, Finland, School of Science	Main supervisor

Research grants awarded in competition

Period	Funder	Project leader	Your role	Sub amount (SEK)	Total amount (SEK)
2020 - 2025	European Union (EU),	Fosca Gianotti	Co-applicant	3 641 029	112 009 971
2020 - 2026	European Union (EU),	Aristides Gionis	Applicant	0	28 002 492
2019 - 2023	Academy of Finland, Not Sweden - Governmental agencies, Finland	Michael Mathioudakis	Co-applicant	6 286 257	12 685 711
2018 - 2021	Academy of Finland, Not Sweden - Governmental agencies, Finland	Aristides Gionis	Co-applicant	7 175 874	14 774 798
2018 - 2019	Academy of Finland, Not Sweden - Governmental agencies, Finland	Aristides Gionis	Applicant	0	3 763 591
2015 - 2019	European Union (EU),	Fosca Gianotti	Co-applicant	4 760 423	56 004 985
2015 - 2019	Academy of Finland, Not Sweden - Governmental agencies, Finland	Aristides Gionis	Applicant	0	7 122 803

Awards and distinctions

Year	Country	Name of award/distinction	Issuer	Description
2023	United States	Best foundational paper award	SIAM Conference on Data Mining (SDM) 2023	Best paper award on foundational and theoretical research, awarded in the SIAM Conference on Data Mining (SDM) 2023 for the paper “Ranking with submodular functions on the fly”

Year	Country	Name of award/distinction	Issuer	Description
2018	United Kingdom	Best paper award	Machine Learning on Graphs (MLG) workshop	Best paper award for the paper “From acquaintance to best friend forever: robust and fine-grained inference of social-tie strengths”, published in the Machine Learning on Graphs (MLG) 2018 workshop, colocated with ACM SIGKDD 2018
2018	United States	Test-of-time paper award	ACM Web Search and Data Mining (WSDM) conference	Test-of-time paper award, awarded in the WSDM 2018 conference for the paper "Finding high-quality content in social media" published in 2008
2017	United States	Best student paper award	ACM Web Science 2017	Best student paper award for the paper “The effect of collective attention on controversial debates on social media” published in the ACM Web Science 2017 conference. The student author is my PhD student Kiran Garimella.
2017	United Kingdom	Best student paper award	ACM Web Search and Data Mining (WSDM) 2017 conference	Best student paper award for the paper “Reducing controversy by connecting opposing views” published in the ACM Web Search and Data Mining (WSDM) 2017 conference. The student author is my PhD student Kiran Garimella.

Year	Country	Name of award/distinction	Issuer	Description
2014	France	Best student paper award	ECMLPKDD 2014	Best student paper award for the paper "Discovering dynamic communities in interaction network" published in the European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECMLPKDD) 2014. The student author is my (at that time MSc student and later PhD) student Polina Rozenshtein.
2009	Hong Kong	Best paper award	ACM Conference on Information and Knowledge Management (CIKM) 2009	Best paper award for the paper "On the feasibility of multi-site web search engines" published in the ACM Conference on Information and Knowledge Management (CIKM) 2009.
2009	Hong Kong	Best student paper award	ACM Conference on Information and Knowledge Management (CIKM) 2009	Best student paper award for the paper "Fast shortest path distance estimation in large network" published in the ACM Conference on Information and Knowledge Management (CIKM) 2009. The student author is Michalis Potamias, my intern student in Yahoo! Research.

Year	Country	Name of award/distinction	Issuer	Description
2004	Italy	Best paper award	ECMLPKDD 2004	Best student paper award for the paper “The discrete-basis problem” published in the European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECMLPKDD) 2004.

Other merits

Period	Type of merit	Description
2020 - 2027	Wallenberg chair professorship	Awarded a Wallenberg chair professorship in KTH Royal Institute of Technology
2020 - 2026	ERC Advanced Grant	Awarded an ERC Advanced Grant, call of 2018, project started in 2020. The title of the project is "An algorithmic framework for reducing bias and polarization in online media (REBOUND)"
2018 - 2024	Journal associate editor	Associate editor for the ACM Transactions on the Web (TWEB) (2018--present)
2023 - 2024	PC chair	Program committee chair in ACM Web Search and Data Mining (WSDM) 2024 conference
2017 - 2024	Journal action editor	Action editor for Data Mining and Knowledge Discovery (DMKD) (2017--present)
2010 - 2024	PhD examiner	Examiner in 30 PhD dissertation committees in many different universities and countries
2005 - 2024	Tutorials and summer schools	Organized and delivered about 25 tutorials in international conferences and mini-courses in summer schools
2024 - 2024	Invited talk	Invited talk in the Austrian Computer Science Day.
2023 - 2023	Invited talk	Invited talk in the Integrity workshop, co-located with ACM Web Search and Data Mining (WSDM) 2023
2021 - 2022	PC chair	Program committee chair in ACM Web Confenrece (WebConf) 2022
2018 - 2021	Fellowship in ISI Foundation	Fellowship awarded by the Institute for Scientific Interchange Foundation (ISI Foundation) in Italy
2014 - 2021	Journal associate editor	Associate editor for the ACM Transactions of Knowledge and Data Discovery (TKDD)
2019 - 2019	Invited talk	Invited talk in the EPFL distinguished lecture series
2018 - 2018	Invited talk	Invited talk in the ECMLPKDD Conference, in Dublin, Ireland
2018 - 2018	Invited talk	Invited talk in the Complex Networks conference, in Cambridge, UK
2018 - 2018	Invited talk	Invited talk in the Machine Learning and Data Analytics (MLDAS) Symposium, in Doha, Qatar
2017 - 2017	Invited talk	Invited talk in the NeurIPS workshop on prioritising online content, in Long Beach, CA, USA
2012 - 2016	Journal associate editor	Associate editor for the IEEE Transactions of Knowledge and Data Engineering (TKDE)

Period	Type of merit	Description
2012 - 2013	PC chair	Program committee chair in ACM Web Search and Data Mining (WSDM) 2013 conference

Intellectual property

Intellectual property					
Type	**Date of approval**	**Status**	**ID**	**Licensed to other part**	**Product classification**
Patent	2016-11-08	Approved	US9489448B2	Not Sweden - Company	62. Computer programming, consultancy and related services
Patent	2015-03-31	Approved	US8996622B2	Not Sweden - Company	62. Computer programming, consultancy and related services
Patent	2014-03-11	Approved	US8671141B2	Not Sweden - Company	62. Computer programming, consultancy and related services
Patent	2014-02-25	Approved	US8660975B2	Not Sweden - Company	62. Computer programming, consultancy and related services
Patent	2013-01-01	Approved	US8346686B2	Not Sweden - Company	62. Computer programming, consultancy and related services
Patent	2012-01-10	Approved	US8095545B2	Not Sweden - Company	62. Computer programming, consultancy and related services
Patent	2011-05-17	Approved	US7945565B2	Not Sweden - Company	62. Computer programming, consultancy and related services
Patent	2011-02-15	Approved	US7890488B2	Not Sweden - Company	62. Computer programming, consultancy and related services
Patent	2007-07-31	Approved	US7251648B2	Not Sweden - Company	62. Computer programming, consultancy and related services
Patent	2006-07-18	Approved	US7080314B1	Not Sweden - Company	62. Computer programming, consultancy and related services

Publications

Publications - Gionis, Aristides

Project leader: Aristides Gionis	**Doctoral degree:** 2003-07-02
Birthdate: 19720926	**Academic title:** Professor
Gender: Male	**Employer:** Kungliga Tekniska högskolan
Country: Sweden	

Register

Terms and conditions

The application shall be signed by the applicant and also by an authorised representative of the administrating organisation. The representative is normally the head of the department where the research will be carried out, but this is dependent on the administrating organisation's structure.

The *applicant's* signature confirms that

- the information in the application is correct and complies with the Swedish Research Council's instructions
- secondary occupations and commercial ties have been reported to the administrating organisation and that nothing has emerged that breaches good research practice
- the permits and approvals required have been obtained before the research is started, such as permits from the Swedish Medical Products Agency or approval from The Swedish Ethical Review Authority or an ethical committee on animal experiments
- the applicant will comply with all other conditions applicable to the grant.

The signature of the *administrating organisation* confirms that

- the research or research-supporting activities described can be given room at the administrating organisation during the period and to the extent stated in the application
- the applicant will be employed by the administrating organisation during the period covered by the application
- the administrating organisation approves of the budget in the application
- the administrating organisation will comply with all other conditions applicable to the grant.

The above points shall have been discussed by the parties before the representative of the administrating organisation approves and signs the application.