In this issue of *IEEE Control Systems*, we speak with Shahriar Talebi, who recently completed his dissertation, titled "Constrained Policy Synthesis: Riemannian Flows, Online Regulation, and Distributed Games," at the University of Washington (UW). His Ph.D. supervisor is Mehran Mesbahi.

He received his Ph.D. degree in aeronautics and astronautics (focusing on control theory) and his M.Sc. degree in mathematics (specializing in differential geometry) from UW, Seattle, WA, USA, in 2023. He holds a B.Sc. degree from Sharif University of Technology, Tehran, Iran, and an M.Sc. degree from the University of Central Florida (UCF), Orlando, FL, USA, both in electrical engineering. He is currently a postdoctoral fellow at Harvard's John A. Paulson School of Engineering and Applied Sciences since September 2023. His research interests include control theory, differential geometry, game theory, learning, and networked systems.

Rodolphe Sepulchre

SHAHRIAR TALEBI

Q. How would you pitch your Ph.D. dissertation in one paragraph?

Shahriar: My Ph.D. dissertation is centered around control and decision making for data-driven and distributed systems, harnessing the synergy of control theory, differential geometry, game theory, and statistical learning techniques. Within my dissertation, I delve into the realm of the Riemannian geometry of feedback policies, uncovering its implications for closed-loop performance metrics. This geometric framework enables handling linear policy constraints and gleans unique insights into learning algorithms tailored for structured and output optimal control problems. Furthermore, through a modular distributed model-free learning algorithm, I develop feedback mechanisms for networks of unknown homogeneous systems, ensuring efficiency at scale by combining robust control techniques with a semigroup structure. The incorporation of online and limited data into decision-making processes facilitates identification and online stabilization with finite-time guarantees. In this direction, I introduce new system-theoretic notions that capture the essence of finite-time performance, distinct from stabilizability or controllability, shedding light on learning and stabilizing systems while averting exponential growth due to unstable modes. Then, I present a synthesis procedure for the online stabilization of (partially) unknown unstable linear systems. Lastly, I tackle the problem of learning optimal filtering policies for linear systems with unknown noise statistics using only output data, all viewed through the lens of estimation-control duality.

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Q. How would you describe the significance and relevance of your results?

Shahriar: You see, control theory has evolved and branched out for decades, successfully untangling a wide array of problems across various fields. But here's the twist—recent challenges have thrown some interesting curveballs for the field. My work aims to address some of these challenges. On the one hand, I delve into characterizing relevant fundamental limitations, like what I called *regularizability* in online stabilization. On the other hand, I leverage the inherent geometry and structures of these problems to develop efficient control and learning algorithms. And here's the kicker—we can indeed utilize the intricate geometric properties in our design problems to come up with scalable algorithms based on inherent structures in centralized and distributed control and estimation problems.

Q. How would you summarize the experience of your Ph.D.?

Shahriar: Reflecting on my Ph.D. journey, I can't help but feel a profound sense of privilege. Over the course of this remarkable experience, I've had the incredible opportunity to traverse a diverse range of disciplines, tackling interesting challenges, collaborating with brilliant minds, and engaging in both teaching and mentorship.

The Ph.D. journey is a mosaic, woven together by countless factors that align in unique ways. Having been blessed with such a constellation of opportunities, I recognize it as an invaluable gem. I recall being asked a similar question during my graduation ceremony, to which I quipped, "I feel so privileged that I'd gladly embark on another Ph.D. with Mehran right now!" The ensuing laughter from the audience captured the sentiment, though even those words fell short of truly encapsulating the depth of my feelings.

Q. Can you describe a moment of frustration or discouragement during your Ph.D. and how you overcame the challenge?

Shahriar: Amid my Ph.D. journey, a moment of frustration stands out. I had invested considerable time tackling an intricate open problem, resolving multiple challenges, and refining arguments. The challenge was eventually distilled down to a single pivotal step within my induction argument.

However, despite intense efforts, this step seemed impervious to all my attempts at cracking it. Doubt crept in, and I questioned the worth of my efforts. Reflecting back, I found solace in the knowledge gained through the

process. While immediate success remained elusive, the experience itself was an invaluable lesson. It restored my hope that the breakthrough might still be possible down the road.

Q. Can you highlight some key reference(s) or article(s) that inspired your research?

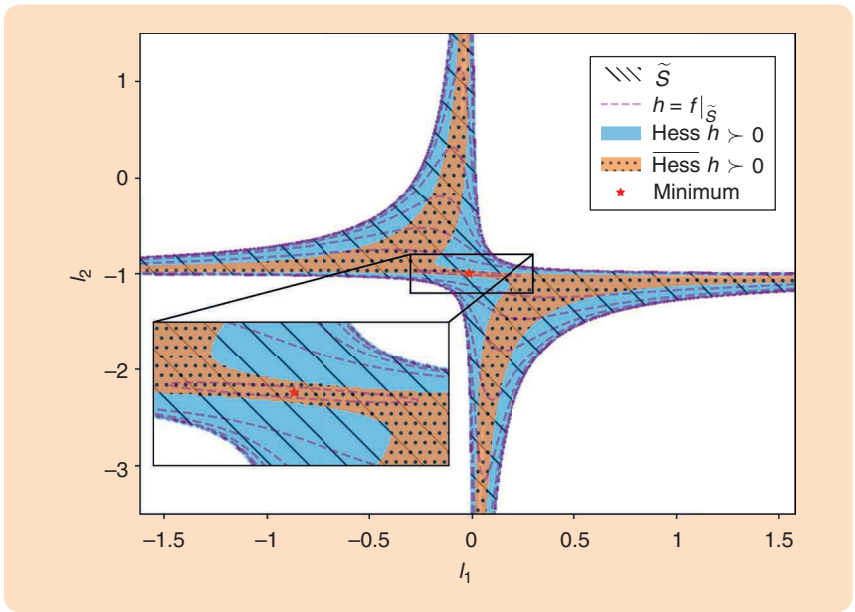
Shahriar: A pivotal inspiration came from my master's advisor, illuminating the intricacies of deriving Pontryagin's principle through the calculus of variations and its deep connection to the principle of optimality. Then, his remarkable work in Simaan and Cruz [1], [2] struck me deeply by revealing how Stackelberg games can breach the principle of optimality, a phenomenon known as *dynamic inconsistency*. Beyond its interdisciplinary impact, this was one of the instances that taught me the art of clear yet profound thinking. I envision him crafting it, employing foundational principles to venture into uncharted territories.

Countless similar works have influenced me, though I'll mention a few more. Rahmani et al. [3] showcase how graph symmetries characterize the controllability/observability of diffusion dynamics on graphs, effectively bridging insights across disciplines. Elia [4] links the Shannon capacity to Bode's sensitivity integral, shedding light on the fundamental limitations of causal feedback. I was also influenced by Nesterov's smoothing technique and its follow-up general treatment of primal-dual algorithms in Nesterov [5], [6]. Also, my perspective has been significantly shaped by the enthralling realm of differential geometry, particularly through John M. Lee's captivating approach in his remarkable textbooks and lecture series on manifolds.

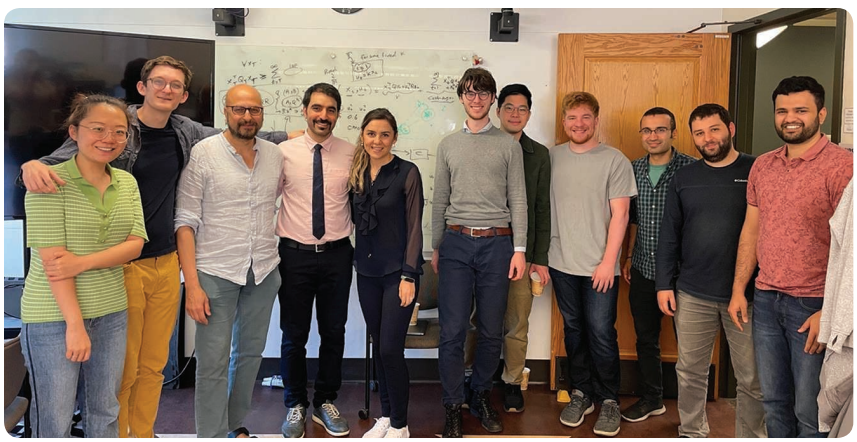
Q. What would you do differently if you were to start your Ph.D. again?

Shahriar: Only after immersing myself in several diverse projects and through the invaluable supervision of my Ph.D. advisor, I uncovered an efficient workflow that I wish I had known from the start. It may begin

Shahriar ready for his Ph.D. ceremony in front of the fountain at the famous Rainier Vista, UW, Seattle, 2023.



The landscape of optimizing the linear–quadratic regulator cost for structured feedback policy through the lens of Riemannian (blue) versus Euclidean (orange) geometries.



Shahriar wearing a tie next to his Ph.D. advisor, Mehran Mesbahi, and his wife, Meli, accompanied by other aeronautics and astronautics fellows right after his Ph.D. defense talk, Robotics, Aerospace and Information Networks LAB, University of Washington (UW), Seattle, WA, USA, 2023.

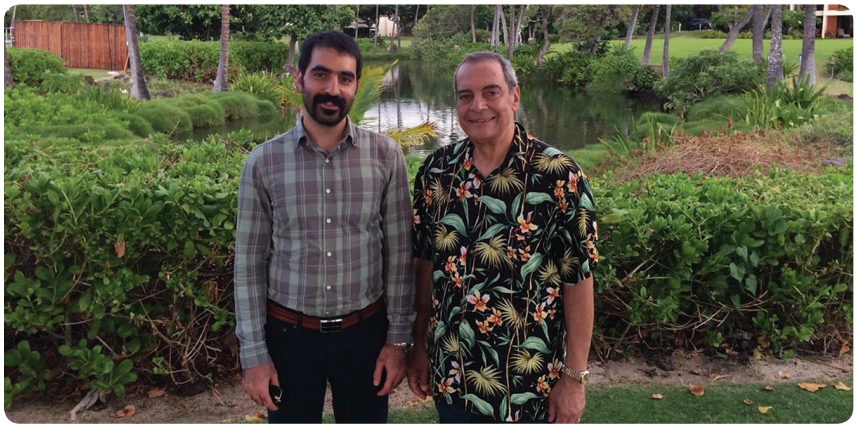
with casual conversations in hallways, often branching off into tangential topics. From there, the process evolves, leading to the crystallization of a concrete problem statement. Progressing further, it involves crafting a rigorous approach that eventually culminates in a solution worthy of presentation.

Throughout this journey, I could observe what we might call the *flow of creativity*. In some phases, my imagination took flight, allowing me to explore innovative avenues. Conversely, other stages required a more restrained approach, demanding a meticulous connection between visible dots of ideas.

For me, the crux lies in recognizing the significance of each stage while maintaining a delicate equilibrium. Although this may seem graspable primarily through direct experience, I'm actively engaged in sharing this experience with my junior peers. My aspiration is to articulate this process effectively, thereby enabling them to navigate their own paths more adeptly.

Q. Can you highlight a most promising topic or area of research for a new Ph.D. student in control?

Shahriar: I think the landscape of control research is continually evolving. The contemporary challenges in systems and control theory often share roots with established design paradigms but possess unique nuances, occasionally necessitating inventive methodologies to bridge fundamental gaps. In this dynamic environment, one noteworthy domain is the realm of gray-box optimal and robust control problems. Such classes of problems not only grapple with uncertain models and dynamic environments but also introduce the complexity of maintaining performance while satisfying critical constraints, thereby necessitating the systematic integration of real-time data in the feedback loop. Moreover, conflicting objectives arise naturally in these contexts, an interplay that is best captured by (non-)cooperative modeling. I believe we have the chance to not only unearth unexplored pathways within these realms but also uncover new fundamental boundaries that could significantly streamline our scientific pursuits.



(From left) Shahriar next to his master's advisor, Prof. Marwan Simaan, at IEEE Conference on Control Technology and Applications (CCTA), Hawai'i 2017.

(From left) Shahriar next to the legendary kamancheh player Kayhan Kalhor at a concert, Orlando, FL, USA, 2017.

Q. What would be your main advice to a prospective Ph.D. student in control?

Shahriar: In the whirlwind of rapidly evolving research and knowledge, we should remember that some of the top-quality ideas/results tend to blossom in moments of tranquility and contemplation. While you're diving headfirst into research, remember to also create valuable pockets of quiet reflection and learning. It might sound like a puzzle, but striking this balance between active engagement and serene introspection is a must. Even though it might not come naturally, it's a skill you'll learn to actively nurture on your journey.

Equally important is fostering a sense of community. In the marathon of research, it's easy to lose sight of the fact that we're not alone in this journey. It's a shared pursuit. In moments of isolation, remember that reaching out to peers can offer not just camaraderie but also fresh perspectives. Our collective goal is to unravel solutions to meaningful challenges, and in this endeavor, we are all together. So, consider this your warm welcome to our amazing control community!

(continued on p. 167)

Financial Impact: None
Endorsed by: Executive Committee

Motion

Move to approve the new and continuing members of the Editorial Board of the IEEE Control Systems magazine, effective January 1st 2024.

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Endorsed by: Executive Committee
Financial Impact: None.

» Ph.D.s IN CONTROL *(continued from p. 130)*

For Further Information About Shahriar's Dissertation

Link to the Dissertation PDF: http://students.washington.edu/shahriar//assets/pdf/uwthesis.pdf

KEY PUBLICATIONS:

- S. Talebi and M. Mesbahi, "Policy optimization over submanifolds for linearly constrained feedback synthesis," *IEEE Trans. Autom. Control*, early access, 2023, doi: 10.1109/TAC.2023.3306384.
- S. Talebi et al., "On regularizability and its application to online control of unstable LTI systems," *IEEE Trans. Autom. Control*, vol. 67, no. 12, pp. 6413–6428, Dec. 2022, doi: 10.1109/TAC.2021.3131148.
- S. Talebi et al., "Duality-based stochastic policy optimization for estimation with unknown noise covariances," in *Proc. Amer. Control Conf. (ACC)*, 2023, pp. 622–627. [Online]. Available: https://arxiv.org/pdf/2210.14878.pdf
- S. Talebi et al., "Distributed model-free policy iteration for networks of homogeneous systems," in *Proc. 60th IEEE Conf. Decis. Control (CDC)*, 2021, pp. 6970–6975, doi: 10.1109/CDC45484.2021.9683331.

AWARDS AND RECOGNITIONS:

- 2022 Excellence in Teaching Award at the University of Washington (UW)
- William E. Boeing Endowed Fellowship (2019)
- Paul A. Carlstedt Endowment (2018)
- Latvian Arctic Pilot
- A. Vagners Memorial Scholarship (2018)
- Frank Hubbard Engineering Scholarship (2017).

Q. Thank you for your comments.

Shahriar: It was my pleasure. Thank you.

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[1] M. Simaan and J. B. Cruz Jr., "On the Stackelberg strategy in nonzero-sum games," *J. Optim. Theory Appl.*, vol. 11, pp. 533–555, May 1973, doi: 10.1007/BF00935665.
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[3] A. Rahmani, M. Ji, M. Mesbahi, and M. Egerstedt, "Controllability of multi-agent systems from a graph-theoretic perspective," *SIAM J. Control Optim.*, vol. 48, no. 1, pp. 162–186, 2009, doi: 10.1137/0606749092009.
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