## Today's Themes (AI-Generated)

• Transferability of HRI research from academia to industry  
• Equivalence of optimization and filtering for state estimation in sensor fusion   
• Volume Transfer design improving wearability of fabric pneumatic exosuits  
• Responsive walking and kicking for humanoid soccer robots  
• Parallel trajectory optimization for navigation in dynamic environments

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## Summaries

[Transferability of HRI Research: Potential and Challenges](http://arxiv.org/abs/2401.05802) [[PDF](http://arxiv.org/pdf/2401.05802)]

by Wafa Johal

With advancement of robotics and artificial intelligence, applications for robotics are flourishing. Human-robot interaction (HRI) is an important area of robotics as it allows robots to work closer to humans (with them or for them). One crucial factor for the success of HRI research is transferability, which refers to the ability of research outputs to be adopted by industry and provide benefits to society. In this paper, we explore the potentials and challenges of transferability in HRI research. Firstly, we examine the current state of HRI research and identify various types of contributions that could lead to successful outcomes. Secondly, we discuss the potential benefits for each type of contribution and identify factors that could facilitate industry adoption of HRI research. However, we also recognize that there are several challenges associated with transferability, such as the diversity of well-defined job/skill-sets required from HRI practitioners, the lack of industry-led research, and the lack of standardization in HRI research methods. We discuss these challenges and propose potential solutions to bridge the gap between industry expectations and academic research in HRI.

[On State Estimation in Multi-Sensor Fusion Navigation: Optimization and Filtering](http://arxiv.org/abs/2401.05836) [[PDF](http://arxiv.org/pdf/2401.05836)]

by Feng Zhu, Zhuo Xu, Xveqing Zhang, Yuantai Zhang, Weijie Chen, Xiaohong Zhang

The essential of navigation, perception, and decision-making which are basic tasks for intelligent robots, is to estimate necessary system states. Among them, navigation is fundamental for other upper applications, providing precise position and orientation, by integrating measurements from multiple sensors. With observations of each sensor appropriately modelled, multi-sensor fusion tasks for navigation are reduced to the state estimation problem which can be solved by two approaches: optimization and filtering. Recent research has shown that optimization-based frameworks outperform filtering-based ones in terms of accuracy. However, both methods are based on maximum likelihood estimation (MLE) and should be theoretically equivalent with the same linearization points, observation model, measurements, and Gaussian noise assumption. In this paper, we deeply dig into the theories and existing strategies utilized in both optimization-based and filtering-based approaches. It is demonstrated that the two methods are equal theoretically, but this equivalence corrupts due to different strategies applied in real-time operation. By adjusting existing strategies of the filtering-based approaches, the Monte-Carlo simulation and vehicular ablation experiments based on visual odometry (VO) indicate that the strategy adjusted filtering strictly equals to optimization. Therefore, future research on sensor-fusion problems should concentrate on their own algorithms and strategies rather than state estimation approaches.

[Volume Transfer: A New Design Concept for Fabric-Based Pneumatic Exosuits](http://arxiv.org/abs/2401.05881) [[PDF](http://arxiv.org/pdf/2401.05881)]

by Chendong Liu, Dapeng Yang, Jiachen Chen, Yiming Dai, Li Jiang, Hong Liu

The fabric-based pneumatic exosuit is now a hot research topic because it is lighter and softer than traditional exoskeletons. Existing research focused more on the mechanical properties of the exosuit (e.g., torque and speed), but less on its wearability (e.g., appearance and comfort). This work presents a new design concept for fabric-based pneumatic exosuits Volume Transfer, which means transferring the volume of pneumatic actuators beyond the garments profile to the inside. This allows for a concealed appearance and a larger stress area while maintaining adequate torques. In order to verify this concept, we develop a fabric-based pneumatic exosuit for knee extension assistance. Its profile is only 26mm and its stress area wraps around almost half of the leg. We use a mathematical model and simulation to determine the parameters of the exosuit, avoiding multiple iterations of the prototype. Experiment results show that the exosuit can generate a torque of 7.6Nm at a pressure of 90kPa and produce a significant reduction in the electromyography activity of the knee extensor muscles. We believe that Volume Transfer could be utilized prevalently in future fabric-based pneumatic exosuit designs to achieve a significant improvement in wearability.

[RoboCup 2023 Humanoid AdultSize Winner NimbRo: NimbRoNet3 Visual Perception and Responsive Gait with Waveform In-walk Kicks](http://arxiv.org/abs/2401.05909) [[PDF](http://arxiv.org/pdf/2401.05909)]

by Dmytro Pavlichenko, Grzegorz Ficht, Angel Villar-Corrales, Luis Denninger, Julia Brocker, Tim Sinen, Michael Schreiber, Sven Behnke

The RoboCup Humanoid League holds annual soccer robot world championships towards the long-term objective of winning against the FIFA world champions by 2050. The participating teams continuously improve their systems. This paper presents the upgrades to our humanoid soccer system, leading our team NimbRo to win the Soccer Tournament in the Humanoid AdultSize League at RoboCup 2023 in Bordeaux, France. The mentioned upgrades consist of: an updated model architecture for visual perception, extended fused angles feedback mechanisms and an additional COM-ZMP controller for walking robustness, and parametric in-walk kicks through waveforms.

[Topology-Driven Parallel Trajectory Optimization in Dynamic Environments](http://arxiv.org/abs/2401.06021) [[PDF](http://arxiv.org/pdf/2401.06021)]

by Oscar de Groot, Laura Ferranti, Dariu Gavrila, Javier Alonso-Mora

Ground robots navigating in complex, dynamic environments must compute collision-free trajectories to avoid obstacles safely and efficiently. Nonconvex optimization is a popular method to compute a trajectory in real-time. However, these methods often converge to locally optimal solutions and frequently switch between different local minima, leading to inefficient and unsafe robot motion. In this work, We propose a novel topology-driven trajectory optimization strategy for dynamic environments that plans multiple distinct evasive trajectories to enhance the robot's behavior and efficiency. A global planner iteratively generates trajectories in distinct homotopy classes. These trajectories are then optimized by local planners working in parallel. While each planner shares the same navigation objectives, they are locally constrained to a specific homotopy class, meaning each local planner attempts a different evasive maneuver. The robot then executes the feasible trajectory with the lowest cost in a receding horizon manner. We demonstrate, on a mobile robot navigating among pedestrians, that our approach leads to faster and safer trajectories than existing planners.