ICFT 2026 - SPECIAL SESSION PROPOSAL

Sociomorphic Systems:
Collective Cognition, Social Embeddedness, and Adaptive Robotics

Organized by
Prof. Dr. Jürgen Graf (Trier University of Applied Sciences) ·
Prof. Dr. Stefan M. Schulz (University of Trier) ·
Prof. Dr. Rami Alazrai *(*Abdullah Al Salem University, Kuwait*)*
Assoc. Prof. Dr. Sahar Qadaan (German Jordanian University)

1. Organizers

Prof. Dr. Jürgen Graf	**Prof. Dr. Stefan M. Schulz**	**Prof. Dr. Rami Alazrai**	**Assoc. Prof. Dr. Sahar Qadaan**
Prof. Dr. Jürgen Graf is Professor in the Department of Computer Science at Trier University of Applied Sciences, where he heads the Cognitive Systems and Robotics Lab. His research spans cognitive robotics, computer vision, artificial intelligence, navigation, and uncertainty aware autonomous systems, with particular emphasis on collective scene interpretation, collective navigation, and intelligent robotic behaviour in complex real-world environments. Drawing on substantial academic and industrial experience, he contributes the session's core perspective on collective cognition, robotic architectures, and adaptive assistive robotics.	Prof. Dr. Stefan M. Schulz is Professor of Behavioural Medicine and Principles of Human Biology for the Health Sciences at Trier University. His work contributes the psychosocial and behavioural medicine perspective to the session, particularly regarding psychosocial stress, cognitive load, and the empirical foundations of human–technology interaction in healthcare contexts. His expertise includes the integration of self-report measures with psychophysiological and EEG-based assessment approaches to investigate cognitive and affective processes in complex interaction settingsrelevant to the development and evaluation of physiologically informed, interaction-sensitive assistive systems in nursing.	Prof. Dr. Rami Alazrai is Professor of Computer Engineering at the German Jordanian University and founder and director of the Human-Centered Computing Lab. His research focuses on brain–computer interfaces and EEG signal analysis, with particular emphasis on decoding motor imagery, pain perception, and human emotions. He contributes the session's foundational technical perspective on neural intent decoding and physiologically grounded human–robot co-action, directly anchoring the BCI-integrated Sociomorphic platforms central to the architectural proposal.	Dr. Sahar Qaadan is Associate Professor in the School of Applied Technical Sciences at the German Jordanian University and Vice Dean of Scientific Research. Her research focuses on machine learning and AI, with emphasis on interdisciplinary and real-world applications. She contributes an international and human-centred perspective to the session, with particular relevance to assistive AI and socially responsive intelligent systems. Her work additionally encompasses adaptive signal processing and biosignal classification in brain-computer interface contexts, directly relevant to the neuroadaptive control architectures of BCI-integrated Sociomorphic platforms.

2. Motivation and Timeliness

Robotics is entering a phase in which collective, socially embedded, and safety-critical operation in human environments can no longer be treated as a peripheral concern. Care settings, rehabilitation environments, public infrastructures, and collaborative workspaces increasingly require systems that do not merely act autonomously as isolated units, but coordinate across embodied agents, exchange uncertainty-aware knowledge, and remain intelligible to human stakeholders.

This special session proposes Sociomorphic Systems as a rigorous and open research framework for that challenge. The term designates collectives of cognitively capable robotic agents whose organisation is shaped not by simple aggregation, but by explicit role differentiation, distributed knowledge, communication, and socially legible coordination. The objective is not rhetorical anthropomorphism, but an engineering vocabulary for collective cognition under real conditions of partial observability, normative constraints, and interaction with vulnerable or non-expert users.

Definition: In the present context, a Sociomorphic System is understood as a collective of embodied cognitive agents characterised by: (i) structured role differentiation with explicit functional semantics; (ii) uncertainty-aware inter-agent communication as a constitutive substrate of collective decision-making [Habermas, 1984]; (iii) distributed realisation of the cognitive processing stack across multiple physical agents [Chen et al., 2025; Dahiya et al., 2023]; and (iv) normatively constrained, socially intelligible behaviour in human-populated environments [Torras, 2024; Methnani et al., 2024]. Formally, S = (A, R, C, G, K), where A denotes a finite set of agents, R a role structure, C a communication relation, G a shared goal structure, and K a distributed knowledge representation. The definition serves as an analytic scaffold for comparison, design, and evaluation rather than as a closed doctrine; in particular, contributions need not adopt the term 'Sociomorphic Systems' explicitly, provided they engage substantively with the underlying challenges of collective cognition, socially embedded coordination, and human-centred evaluation.

The session is timely for three reasons. First, advanced robotics is shifting from single-agent autonomy toward collaborative perception, distributed decision-making, and multi-agent deployment [Chen et al., 2025; Dahiya et al., 2023]. Second, assistive and care robotics increasingly demand not only technical performance, but trustworthiness, transparency, acceptance, and adaptive social behaviour [Maure and Bruno, 2025; Gul et al., 2025; Cross and Kappas, 2026]. Third, the field still lacks a clear integrative language connecting collective cognition, knowledge representation, psychosocial validation, and system-level evaluation, including metrics, benchmarks, and validation protocols [Methnani et al., 2024; Gul et al., 2025]. This session addresses that gap in a form that is conceptually ambitious, technically grounded, and explicitly open to critical and comparative contributions.

Rather than presenting a closed doctrine, the session is designed as a research forum: it invites formal, algorithmic, empirical, and interdisciplinary work that develops, tests, refines, or challenges the proposed framing. In this sense, Sociomorphic Systems serves as a focal concept for an emerging agenda at the intersection of robotics, AI, HRI, assistive technology, and social-scientific evaluation [Chen et al., 2025; Dahiya et al., 2023; Maure and Bruno, 2025; Cross and Kappas, 2026]. Contributions need not adopt the label explicitly but should engage substantively with the underlying challenges of collective cognition, socially embedded coordination, and human-centred evaluation.

As a first focal point for such contributions, the session offers the following architectural proposal.

Proposal for discussion: The physiologically closed human–robot control loop as a paradigmatic instantiation of Sociomorphic Systems. It is proposed that the paradigm be concretised through an architecture in which a dedicated inference agent estimates the user's internal state — motor intent, cognitive load, attention, trust — from a multimodal cascade of EEG/BCI, peripheral autonomic indicators (HRV, EDA, pupillometry), and sparse self-report anchors, and propagates it as a co-equal epistemic input to the perception, planning, and control agents of the collective [Su et al., 2023; Jin et al., 2024]. The structural significance lies in the formal embedding: the user becomes a constitutive node of the communication topology C in S = (A, R, C, G, K) — decoded states enter the same distributed knowledge representation K as exteroceptive visual systems and modulate the shared goal structure G along the hierarchy *mission planning → motion planning → reactive control*, enabling anticipatory rather than purely reactive co-action. *Shared autonomy* thus appears not as arbitration between isolated controllers but as physiologically grounded co-constitution of the task space in assistive robotics and rehabilitation [Javdani et al., 2018]; trust is assessed by triangulation across physiological, behavioural, and subjective channels, addressing the over-reliance on self-report in current practice [Gul et al., 2025; Cross & Kappas, 2026]. The instantiation delivers both a technical blueprint and a methodological shift: from the operator logic of classical HRI to a cognitive-collective logic in which human interiority is treated as a primary epistemic entity.

Open Research Questions

- How can role semantics be formally specified and dynamically reconfigured under real-world perturbation, and what architectural mechanisms ensure role continuity when individual agents fail or leave the collective? [Graf, 2025; Chen et al., 2025]
- What evaluation criteria are necessary and sufficient for trustworthy Sociomorphic Systems in care and rehabilitation environments, and how can acceptance, transparency, and safety be operationalised as measurable design objectives? [Gul et al., 2025; Maure and Bruno, 2025; Methnani et al., 2024]

- How does uncertainty propagation across agent boundaries affect collective scene interpretation, collective navigation, and collective decision-making quality, and what communication architectures minimise compounding error under partial observability? [Chen et al., 2025; Gielis et al., 2022]
- How can meta-cognitive self-monitoring - the capacity of a collective system to observe and communicate its own epistemic blind spots and model limitations - be realised in distributed agent architectures operating in safety-critical, human-populated environments? [Luhmann, 1984/1995; Dahiya et al., 2023; Methnani et al., 2024]
- How should normative constraints and conflict-resolution mechanisms be formally encoded at the architectural level to ensure socially legible, fair, and accountable collective behaviour, and what formal guarantees can be given that sociomorphic collectives prevent excess - the escalation of local disagreement into system-level breakdown? [Torras, 2024; Methnani et al., 2024]
- How can Brain-Computer-Interfaces (BCI) derived neural signals — encoding motor intent, cognitive load, attentional state, and affective response — be integrated as a first-class communication channel within the role and knowledge structure of a Sociomorphic System to enable neuroadaptive, intent-driven coordination in assistive and rehabilitation contexts, and what architectural mechanisms ensure robustness, transparency, and safety of such integration? [Zander & Kothe, 2011; Kocejko et al., 2024; Campagna & Rehm, 2024]

Paradigm Demarcation (typical emphases). Sociomorphic Systems in relation to established paradigms [Graf, 2025; Debie et al., 2024; Dahiya et al., 2023; Cross and Kappas, 2026].

Paradigm	Collective Cognition	Role Structure	Social Embeddedness	Normative Constraints
Swarm Robotics	emergent, local	typically none	typically no	typically no
Multi-Agent Systems	distributed	functional	limited or application-dependent	optional
Single-Robot Autonomy	complete, monolithic	none	typically no	typically no
Social Robotics	primarily individual	typically none	yes (HRI)	limited or application-dependent
Sociomorphic Systems	**collective, structured**	**explicit**	**yes**	**yes**

3. Scope and Topics

In Scope

- Foundations and conceptual demarcation from swarm robotics, Multi-Agent Systems (MAS), and social robotics
- Distributed cognition across sensing, perception, AI, control, and actuation
- Role structures, functional differentiation, redundancy, and reconfiguration in embodied collectives
- Communication architectures, intent signaling, uncertainty propagation, and coordination protocols
- Scene interpretation, social context awareness, and knowledge representation for distributed systems
- Collective planning, decision-making, socially legible behaviour, and meta-cognitive system design
- Assistive and care robotics, rehabilitation support, and human-centred autonomous platforms
- Evaluation methodologies, trust and acceptance studies, benchmark design, and validation protocols for collective socially embedded systems
- BCI, self-report, peripheral physiology, and EEG for neuroadaptive Sociomorphic Systems; overload detection, grounding, and adaptive fallback in assistive and care environments [Zander & Kothe, 2011; Campagna & Rehm, 2024]

Out of Scope

- Purely instrumental coordination without distributed cognition or meaningful organizational structure
- Swarm systems lacking explicit cognitive architecture or role semantics
- Single-robot autonomy without a collective dimension
- Military autonomous weapon systems

4. Format Plan

- Invited talks (4–5): senior contributions from robotics, assistive AI, cognitive systems, and psychosocial or care-oriented disciplines
- Paper presentations (2–3): selected papers (open call), including emerging and early-career work
- Interdisciplinary panel discussion: moderated debate on conceptual foundations, evaluation, translational barriers, and responsible deployment
- Networking and community-building segment: structured exchange around collaborations, benchmark needs, and future funding or standardisation opportunities

5. Tentative Speaker and Panelist List

Role	Name / Affiliation	Topic Area	Status
Session Chair	**Prof. Dr. Jürgen Graf** Trier Univ. of Applied Sciences	Sociomorphic systems; collective cognition; formal and technical foundations	Confirmed
Session Co-Chair	**Prof. Dr. Stefan M. Schulz** University of Trier	Psychosocial and psychophysiological cofactors of interaction, grounding, and safe deployment in care environments	Confirmed
Session Co-Chair	**Assoc. Prof. Dr. Sahar Qadaan** GJU, Jordan	Human-centred computing; assistive AI; interface and participatory design	Confirmed
Invited Talk	**Collective Robotics Researcher (TBA)**	Distributed cognition across the technical processing stack	In recruitment
Invited Talk	**Care / Rehabilitation Researcher (TBA)**	Assistive deployment, user-centred evaluation, and safety	In recruitment
Invited Talk	**Cognitive Scientist / NLP Researcher (TBA)**	Communication, dialogue, and collective decision support	In recruitment
Invited Talk	**BCI / Neuroadaptive Systems Researcher (TBA)**	Neural intent decoding, passive BCI, and neuroadaptive coordination in assistive human-robot collectives	In recruitment
Panelist	**Industry Representative (TBA)**	Deployment roadmaps, translational constraints, and product perspectives	To be announced
Contributed Papers	**Open call**	All session topics; critical, comparative, extending, and validating contributions welcome	Open call

6. Expected Audience and Impact

The session targets researchers in robotics, AI, HRI, assistive systems, cognitive modelling, knowledge representation, care technology, and social-scientific evaluation. Its principal contribution is to create a credible interdisciplinary forum in which formal system design, empirical validation, comparative analysis, and responsible deployment can be discussed within one coherent agenda. Beyond the immediate conference setting, the session is intended to stimulate shared terminology, sharper evaluation criteria, and durable collaborations across technical and human-centred disciplines.

7. Relevance to ICFT 2026

The proposal aligns directly with ICFT tracks on intelligent systems and robotics, human–computer interaction and assistive technologies, and AI ethics and society. It contributes a focused yet integrative topic that combines technical depth with application relevance and international visibility. The session also offers clear added value to ICFT by bringing together computer science, nursing science, psychology, and human-centred computing in a format that goes beyond isolated talks and supports genuine cross-disciplinary exchange. The integration of brain-computer interface and neuroadaptive systems research additionally extends the session

to ICFT communities working on neural engineering and physiologically adaptive human-machine interaction, addressing a dimension — neurophysiological grounding of collective robot coordination — that has not previously been addressed in this form at ICFT.

8. Session Logistics

Duration	Half-day session (approx. 3.5 hours, including break)
AV / Equipment	Standard AV setup; large display preferred for demos
Hybrid Support	Remote participation for invited speakers and panelists strongly requested
Paper Submissions	6–8 page full papers in ICFT format; peer-reviewed under the conference process

9. Diversity and Balance

The organising team spans Germany and Jordan and integrates complementary expertise from computer science and robotics, nursing science and psychology, and human-centred computing. The session is committed to disciplinary breadth, international visibility, gender balance among invited contributors where feasible, and meaningful inclusion of both academic and applied perspectives. This composition reflects the substantive thesis of the session itself: that socially embedded robotic systems require technically rigorous and genuinely interdisciplinary thinking.

CALL FOR PAPERS

Sociomorphic Systems:

Collective Cognition, Social Embeddedness & Adaptive Assistive Robotics

Special Session @ ICFT 2026

We invite original research contributions on collective cognition, socially embedded robotic systems, assistive and care-oriented autonomy, distributed knowledge and communication architectures, and evaluation frameworks for trustworthy multi-agent operation in human environments. We explicitly welcome theoretical, empirical, comparative, interdisciplinary, and translational submissions, including work that tests, refines, or critically examines the proposed session framing. Contributions need not adopt the term 'Sociomorphic Systems' explicitly, but should engage substantively with the underlying challenges addressed by the session [Chen et al., 2025; Maure and Bruno, 2025; Gul et al., 2025; Methnani et al., 2024].

KEY TOPICS: collective cognition | role differentiation | distributed perception and decision-making | communication and coordination architectures | scene interpretation and social context awareness | knowledge representation | uncertainty-aware planning | assistive robotics and intelligent mobility | trust, acceptance, and psychosocial grounding | ethics, governance, metrics, benchmarks, and validation methodologies [Torras, 2024; Cross and Kappas, 2026]

Submit via Microsoft CMT - Track: Special Sessions. Mark your submission "Sociomorphic Systems Special Session". Format: 6-8 pp full paper (ICFT template). Inquiries: j.graf@hochschule-trier.de

10. Selected References

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