

Executive summary of the CA-RoboCom Project (page 1)

The CA-RoboCom Project is the “Coordination Action” which will design and describe the FET Flagship candidate “Robot Companions for Citizens”

Sustainable welfare through sentient machines:

Addressing the pertinent challenges of humanity through advanced human-scale technology



Humans have moved beyond their evolutionary inheritance by progressively mastering nature through the use of tools and the development of culture. Indeed, our current industrialized societies are far removed from the environments in which early human hunter-gatherers existed. However, the welfare that has been generated in the developed world, by the evolution of human society, is not without challenges and its sustainability is questionable. In our *private environments* we are facing the challenge of maintaining and enhancing our personal physical and psychological welfare. In our *social environments* we face the challenge of overcoming the dehumanizing aspects of the modern world and its technology-dominated utilitarianism. In our *economic environment* we are facing the challenge of finding the labour force that will replace the aging population and allow us to maintain affordable services. In the *urban environments* we face the challenge of maintaining high-quality living conditions. Lastly in our *physical environment* we must address the challenge of conserving the planet that has to sustain humanity and all other forms of life for the foreseeable future. The recent natural and man-made disasters provide compelling illustrations of the challenges that humanity is facing and the limited capabilities of contemporary machines to make significant contributions to their resolution. At first sight the problems emerging in these different environments appear to be unrelated; however they are actually tightly coupled. As a result, specialized domain-specific solutions are unlikely to scale-up to meet the challenge. What is needed is an across-domain, transformative and game-changing innovation. The FET Flagship Initiative “Robot Companions for Citizens” (RCC) proposes such a novel enabling technology—an ecology of sensing and actuated systems and interlinked technologies, that we call *Sentient Machines*. By sentience we mean the integration of perception, cognition, emotion and action with a contextual awareness of self, others and environment. No existing machine is sentient in this sense, even the most advanced robot today falls far short. Sentient Machines will fulfil a variety of assistive roles for humanity thanks to their ability to *act and interact physically, emotionally, socially and safely with humans*. Sentient Machines will be ubiquitous and yet unobtrusive, they will extend the active independent lives of citizens, bolster the labour force, provide key services in our cities, aid us to cope with natural and man-made disasters, maintain our planet, and preserve and support human capabilities and experience. In sum, Sentient Machines are a key enabling technology for the foundation of a **new sustainable welfare**.

RCC proposes that future sustainable welfare must be found in an ecology of sentient machines applied to a multitude of environments. This vision can be realized by a multi-disciplinary federated international effort in research and development. As its core objective this effort will identify the **principles of the embodied perception, cognition,**

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emotion and action of natural sentient systems that make them capable of acting in, interacting with, and adapting to their physical and social environment, and of being sentient of this relationship to the world. RCC will exploit the growing understanding of natural sentience to build an ecology of sentient machines; these may be biomorphic, anthropomorphic or express fully novel body-brain configurations specialized for specific niches. RCC will force the pace of both the realization of these new technologies and of the basic science programme on which they are based. Indeed, the engineering of sentient machines will advance our understanding of the design principles underlying biological sentience in the natural brains and bodies formed by evolution. It will do so by providing unique synthetic methods to test complex integrated system-level hypotheses that have eluded direct empirical evaluation: how matter can give rise to mind, the relationship between mind and body, the coupling of structure and function in biological systems, the mystery of sentience and consciousness. Out of this closed loop between science and engineering a new discipline of sentient machines will emerge encompassing the core science and engineering vision, but also studying how sentient machines can be best deployed in an ethically-sound way. At the societal level this new science will also seek to understand emerging social processes in networks of embodied sentient systems both natural and artificial.

The essential ingredients of the new robotics paradigm that will lead to the realization of Sentient Machines are: soft robotics in its *bodyware* and *mindware* components; knowledge of the fundamental design principles underlying biological bodies and brains; soft-materials sciences and tissue engineering addressing structure, sensing, actuation, mechanical and signal transmission; new paradigms for computation, and, last but not least, energy production, storage and scavenging. RCC is an integrated **science- and engineering-driven** initiative, whose scientific mission is **complex, multiple-disciplinary and broad**.

RCC will advance its broad vision by targeting a limited number of strategically -placed initial demonstrator systems including:

- 1: The sentient machine “collaborator”: a real-world system for personal, domestic, medical, industrial and urban assistance with an “all purpose” humanoid shape.
- 2: The sentient machine “suit”: a wearable system for body power extension for helping people to perform physically demanding jobs, conquer novel physical tasks and environments, or “assist the motion of disabled and elderly people”, or as an actuated health monitoring system.
- 3: The sentient machine “explorer/co-worker”: a system able to walk, swim, and/or fly, able to cooperate with humans in tasks of rescue, and exploration of hostile environments; the “best friend” of mankind in case of floods, forest fires, earthquakes, submarine or nuclear emergencies and other catastrophes;
- 4: The sentient machine “body support and augmentation system”: biomimetic materials and neuromorphic design principles of sensing, control and action to develop and deploy a new generation of adaptive prosthetic systems, for replacement and support of the body, brain and mind.

Driven by its vision and ambition of Sentient Machines, and by means of an appropriate outreach strategy, RCC will involve all pertinent stakeholders—science and technology, society, finance, politics and industry. Given the potential transformative and disruptive effects of RCC in our society, their development and deployment will be based on the broadest possible support platform. RCC envisions a flagship as an incubator of advanced science and engineering where resources are allocated in a competitive fashion to the best ideas that contribute to the realization of sentient machines and their application to create sustainable welfare.