Highlights of this textbook

★ **Consensus systems:** It is a fundamental property of networked systems that agents with integrator dynamics approach a common state whenever the communication graph of the controller includes a spanning tree (Theorems 3.1 and 3.3). This result is independent of the weightings of the graph.

★ **Synchronisation:** Synchronising networked controllers make the agent outputs to approach a common trajectory. Theorem 4.1 provides a simple test showing that the controller has to have a spanning tree and, additionally, to respect the agent dynamics.

★ **Synchronisable agents:** To be synchronisable by a networked controller, the agents have to be stabilisable by a static output feedback (Theorem 4.3). Dynamical local controllers may be used to make agents synchronisable.

★ **Synchronisation of agents with individual dynamics:** The phenomenon of synchronisation has been mainly investigated for agents with identical dynamics. The extension to agents with individual dynamics leads to the Internal-Reference Principle (Theorem 4.4) that requires that the agents have common dynamics in order to be synchronisable.

★ **Sensitivity of synchronised agents:** The synchronisation of linear agents is highly sensitive to parameter variations that make the agents deviate from their common dynamics (Section 4.8). To render the theory of synchronised agents relevant for applications, a larger class of agents has to be considered, like agents with affine dynamics or Kuramoto oscillators.

★ **Communication structure design:** Chapter 5 explains a systematic way to choose the communication structure of networked controllers for efficient set-point following, where all agents should react on a set-point change with a quick transient response. The delay measure introduced in Definition 5.1 proves to be an effective means for a model abstraction that reduces the complexity of the structure design problem.

★ **Adaptive cruise control:** For the distance control of vehicle platoons, it is possible to decompose the requirements (R1) – (R5) on the overall platoon given on p. 299 to get the design objectives (D1) – (D4) on the separate vehicles listed on p. 324. Whenever all controlled vehicles satisfy these design objectives, the platoon is guaranteed to avoid collisions in any traffic situation considered.

★ **Cooperative adaptive cruise control:** For the networked version of the vehicle controllers, Theorem 5.2 provides a systematic way for selecting the communication structure.

★ **Small-world properties of networked control systems:** Large existing networks have the small-world property explained in Chapter 6 saying that, in the average, each vertex is reachable from any other vertex over a short path. Chapters 7 and 8 show how this property can be utilised by networked controllers to satisfy a control aim with randomly chosen communication links.

★ **Self-organisation in networked control systems:** The freedom in the selection of the communication structure of networked controllers can be used to create self-organised systems, in which the agents connect themselves in dependence upon their current control goal over a few communication links. Chapter 8 shows that it is not necessary to use a complete coupling graph, but that a small-world graph with a few number of edges leads to a satisfactory behaviour of the overall system.

★ **Event-triggered control:** Chapter 9 explains how the communication effort within a control loop can be reduced if the feedback loop is closed only after events have indicated a substantial control error. The guaranteed performance bounds given in Theorem 9.1 lead to guidelines on the selection of appropriate event thresholds. Experiments with a thermo-fluid process demonstrate that event-triggered control reduces the sampling frequency drastically (Section 9.3).