**The Different Control Structures**

Centralized control means that all the decision making and control are performed by one entity in the system and the decisions and control actions are disseminated to all the subsystems for execution.

Decentralized control means that a system level controller is divided into several pieces, such that each subsystem takes one set of tasks. It is also said to be hierarchical and could achieve the similar performance of a single system level controller (centralized). The system may fail to run if one subsystem has a fault. It is different from a centralized system as each subsystem has some decision making and control authority given to it.

Distributed control refers to the case where each subsystem has its own intelligence and all are peers without primary-slave relation. Hence, even when one or some subsystems fail, the overall system can still perform the designed task possibly with performance degradation.

Remarks

* As for the extreme case when the network is connected and each subsystem can eventually get the overall information, the kind of system structure this represents depends on whether all the subsystems are peers. This is unlike some definitions in the literature where de-centralised control utilizes only local information in its neighbourhood.
* The term "distributed and hierarchical" means that all subsystems are peers. However, there exists a higher-level decision-making mechanism, e.g., the task assignment.
* Consider the formation flight example where the human operator decides only on the formation shape and trajectory. The structure is said to be centralized if the position of each UAV in the formation and the trajectory of each UAV are computed by one “leader” UAV or by a ground computer and the respective trajectories are disseminated to all the UAVs for execution. It is, on the other hand, de-centralised if the trajectory of each UAV is decided by the UAV itself while the position of each UAV is decided centrally. For it to be distributed, the UAVs individually decide on their own position as well as their own trajectory.
* If a decision and control algorithm that was initially designed for a centralized structure were implemented in every robot after some modification that took into account network properties (e.g. delay) and internal robot structures, this overall structure, by the above definition is distributed and not centralized even though each robot has access to global information to compute the solution.
* In a complex system, centralized structures can emerge temporarily from a distributed structure for particularly tasks. For example, a team of UAVs covering an area receives a request to service a task. A leader can be selected by some distributed protocol and the leader can centrally decide on the UAV to service the task. Overall, the system is still distributed as the decision on which UAV to be selected as leader is by distributed means. The overall system still retains the “no single point of failure” property of a distributed system.