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Chapter 1 : Feedback Control System Analysis and Synthesis by John J. D'Azzo

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The Wright brothers made their first successful test flights on December 17, and were distinguished by their ability to control their flights for substantial periods more so than the ability to produce lift from an airfoil, which was known. Continuous, reliable control of the airplane was necessary for flights lasting longer than a few seconds. By World War II, control theory was becoming an important area of research. A Centrifugal governor is used to regulate the windmill velocity. For example, ship stabilizers are fins mounted beneath the waterline and emerging laterally. In contemporary vessels, they may be gyroscopically controlled active fins, which have the capacity to change their angle of attack to counteract roll caused by wind or waves acting on the ship. The Space Race also depended on accurate spacecraft control, and control theory has also seen an increasing use in fields such as economics. Open-loop and closed-loop feedback control[edit] A block diagram of a negative feedback control system using a feedback loop to control the process variable by comparing it with a desired value, and applying the difference as an error signal to generate a control output to reduce or eliminate the error. Example of a single industrial control loop; showing continuously modulated control of process flow. Fundamentally, there are two types of control loops: In open loop control, the control action from the controller is independent of the "process output" or "controlled process variable" - PV. A good example of this is a central heating boiler controlled only by a timer, so that heat is applied for a constant time, regardless of the temperature of the building. In closed loop control, the control action from the controller is dependent on feedback from the process in the form of the value of the process variable PV. In the case of the boiler analogy, a closed loop would include a thermostat to compare the building temperature PV with the temperature set on the thermostat the set point - SP. This generates a controller output to maintain the building at the desired temperature by switching the boiler on and off. A closed loop controller, therefore, has a feedback loop which ensures the controller exerts a control action to manipulate the process variable to be the same as the "Reference input" or "set point". For this reason, closed loop controllers are also called feedback controllers. The controller is the cruise control, the plant is the car, and the system is the car and the cruise control. A primitive way to implement cruise control is simply to lock the throttle position when the driver engages cruise control. However, if the cruise control is engaged on a stretch of flat road, then the car will travel slower going uphill and faster when going downhill. As a result, the controller cannot compensate for changes acting on the car, like a change in the slope of the road. The difference, called the error, determines the throttle position the control. Now, when the car goes uphill, the difference between the input the sensed speed and the reference continuously determines the throttle position. As the sensed speed drops below the reference, the difference increases, the throttle opens, and engine power increases, speeding up the vehicle. The central idea of these control systems is the feedback loop, the controller affects the system output, which in turn is measured and fed back to the controller. Classical control theory[edit] Main article: Classical control theory To overcome the limitations of the open-loop controller, control theory introduces feedback. A closed-loop controller uses feedback to control states or outputs of a dynamical system. Its name comes from the information path in the system: Closed-loop controllers have the following advantages over open-loop controllers: In such systems, the open-loop control is termed feedforward and serves to further improve reference tracking performance. A common closed-loop controller architecture is the PID controller. Closed-loop transfer function[edit] Further information: The controller C then takes the error e difference between the reference and the output to change the inputs u to the system under control P . This is shown in the figure. This kind of controller is a closed-loop controller or feedback controller. In such cases variables are represented through vectors instead of simple scalar values. For some distributed parameter systems the vectors may be infinite-dimensional typically functions. If we assume the controller C , the plant P , and the

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sensor F are linear and time-invariant i. This gives the following relations:

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