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PID feedback controller used as a tactical asset allocation technique: The G.A.M. model ☆

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Abstract

The objective of this paper is to illustrate a tactical asset allocation technique utilizing the PID controller. The proportional–integral–derivative (PID) controller is widely applied in most industrial processes; it has been successfully used for over 50 years and it is used by more than 95% of the plants processes. It is a robust and easily understood algorithm that can provide excellent control performance in spite of the diverse dynamic characteristics of the process plant.

In finance, the process plant, controlled by the PID controller, can be represented by financial market assets forming a portfolio. More specifically, in the present work, the plant is represented by a risk-adjusted return variable. Money and portfolio managers' main target is to achieve a relevant risk-adjusted return in their managing activities. In literature and in the financial industry business, numerous kinds of return/risk ratios are commonly studied and used.

The aim of this work is to perform a tactical asset allocation technique consisting in the optimization of risk adjusted return by means of asset allocation methodologies based on the PID model-free feedback control modeling procedure. The process plant does not need to be mathematically modeled: the PID control action lies in altering the portfolio asset weights, according to the PID algorithm and its parameters, Ziegler-and-Nichols-tuned, in order to approach the desired portfolio risk-adjusted return efficiently.

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Keywords: Tactical asset allocation; Buy & hold strategy; PID controller; Feedback systems; Portfolio performance index

1. Objective

The aim of this work is to verify the efficiency of proportional–integral–derivative (PID) controller application to financial management portfolio activity. The PID controller is widely applied in most industrial

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processes; it has been successfully used for over 50 years and it is used by more than 95% of the plant processes. It is a robust and easily understood algorithm that can provide excellent control performance in spite of the diverse dynamic characteristics of the process plant [1]. In particular, the aim of this paper is to illustrate a new application of a controller system, the G.A.M. model; in this model, a PID controller is applied to a portfolio in order to perform a tactical asset allocation on such portfolio. This work verifies the efficacy and efficiency of PID model-free controlling methods as an asset allocation technique. A PID model-free approach requires the PID controller to get tuned in loop with the given plant to be controlled; whereas, other approaches build a model of the plant and, accordingly, decide the parameters of the controller by deterministic or optimization methods [2]. The controller provides signals to dynamically manage the asset mix of a portfolio. This paper aims to verify the efficiency of the PID controlling action in order to achieve a specific performance measured by a risk-adjusted return indicator. Following the G.A.M. model description, the adopted methodology, results and conclusions will be presented.

2. The G.A.M. model

The G.A.M. model is a technique for allocating a plurality of assets in a portfolio, via tactical asset allocation in order to achieve a long-term target over a desired time horizon. More particularly, the present work relates to a method and system for asset allocation of assets having different degrees of risk and return consisting in the optimization of portfolio risk-adjusted return based on the PID free-model feedback control modeling procedure [3].

In industrial environments such as chemical plants, power plants, and engineering industries, numerous processes need to be tightly controlled to comply with the required specifications for the resulting products. The control of processes in the plant is provided by a process control methodology and apparatus, which typically senses input/output variables. The process control apparatus then compares these variables against desired predetermined values (set-point). If unexpected differences exist or get formed during the plant process, changes are made to the input variables to return the output variables to a predetermined desired range (set-point). Most commonly, the control of a process is provided by a PID controller. PID controllers provide satisfactory control behavior for many single input/single output systems.

The general concept of proportional plus integral plus derivative (PID) control is well known in the art. This type of control was first described in a mathematical context early in the 20th century. In the process control system, a measured process variable is compared with a set point or desired value in a controller to generate an error signal. A control signal generated in the controller as a function of the error signal is applied to a final control element, which regulates the flow of energy into or out of the process.

The four basic types of controllers are (1) the off-on, (2) the integral, (3) the proportional, and (4) the derivative. The off-on type, as the name implies, applies a full-on or full-off signal to the final control element in order to maintain the measured variable near the set point. The proportional controller generates a control signal, which is directly proportional to the magnitude of the error signal. In both the off-on and the proportional controller, the control signal applied to the final control element is zero when the error signal is zero. The integral controller generates a control signal, which is the integral of the error signal. Thus, the rate of change of the control signal is directly proportional to the magnitude of the error signal and the control signal is equal to the area under the time–error signal curve. Since the integral action controller generates a signal, which is a function of the history of the error signal, it maintains a new level after the error returns to zero following a disturbance. This gives the integral controller the capability of eliminating off-set caused by load changes, and for this reason integral control is often referred to as automatic reset control. The not yet fully appreciated advantage of integral control, in addition to the automatic reset feature, is that abrupt changes in the set point are applied gradually to the process through the integral action. In other words, the control signal lags the set point change. The derivative controller generates a control signal, which is the derivative of the error signal. This means that the control signal is directly proportional to the rate of change of the error signal. It is clear then that the control signal generated by this type of controller is equal to zero except when the error is changing, and thus will remain equal to zero in the presence of a constant error signal. The derivative mode generates a control signal, which leads the error signal and, for this reason, is useful in initiating a change in operating conditions in systems having prolonged time constants. In practice, two or