# Intermittent Sampling in Repetitive Control: Exploiting Time-Varying Measurements

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## 1 Background

Repetitive control (RC) is a feedback control method that significantly reduces periodic errors, which result from periodic disturbances or references, by learning from past executions of the same task [1]. Both RC and iterative learning control (ILC) are based on the internal model principle (IMP) [2]. However, in RC, the initial condition of the current task carries over from the previous task, as opposed to ILC, in which the initial condition is the same for each task. An extensive RC framework has been developed for equidistant error data resulting from a discrete time, linear time-invariant (LTI) system [3], with frequency domain stability tests and design procedures using non-parametric models, i.e., identified frequency response functions (FRF).

## 2 Problem Formulation

In many industrial applications, a measurement of the error is often not available at each time step, but the time instance of the measurement, i.e. its timestamp, is available, resulting in non-equidistant (intermittent) but exact measurement data. Relevant examples include optical encoders that output the exact position at line transitions [4], and networked control systems subject to packet loss or cyberattacks.

The aim of this work is to develop a new repetitive control framework for this intermittent sampling setting, combining the traditional RC setup and a timestamping operator to model the availability of data at each timestep.

## 3 Results

The developed RC framework guarantees stability of the repetitive controller in the intermittent sampling setting for any realization of the measurements. The stability test can be verified in the frequency domain using a non-parametric model in the form of an identified FRF. This results in an intuitive design framework based on loopshaping techniques, allowing to explicitly address uncertainty in the non-parametric model.

The RC framework is validated on an industrial printbelt system at Canon Production Printing, in which optical sensors are used in combination with a perforated belt to measure the position of the belt. Fig. 1 shows the converged RC error in this intermittent sampling setting, compared to the initial error without RC. The developed RC framework is able to reduce the repetitive error of the printbelt significantly: from $\pm 370$ $\mu$m to $\pm 60$ $\mu$m, a reduction of a factor 6.

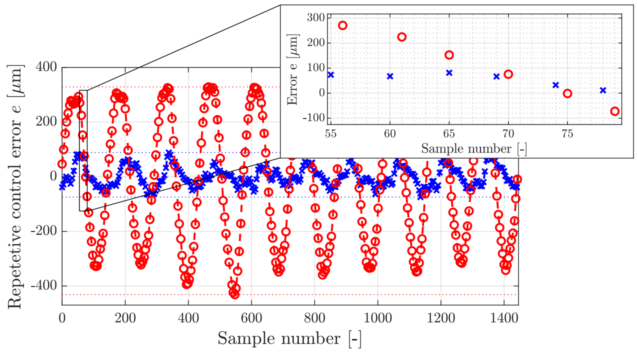


**Fig. 1:** Converged error of the intermittent sampling RC design at timestamps (×), as compared to the error without RC at timestamps (○). It can be observed that the available error is non-equidistant in time. Furthermore, the time instances of the available data vary over different executions of the same task. The linear interpolation of the error is shown in (- -) in the respective color.

## 4 Acknowledgements

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## References

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