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Suppressing intersample behavior in iterative learning control. (English) Zbl 1162.93380
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Summary: Iterative Learning Control (ILC) is a control strategy to improve the performance of digital batch repetitive processes. Due to its digital implementation, discrete time ILC approaches do not guarantee good intersample behavior. In fact, common discrete time ILC approaches may deteriorate the intersample behavior, thereby reducing the performance of the sampled-data system. In this paper, a generally applicable multirate ILC approach is presented that enables to balance the at-sample performance and the intersample behavior. Furthermore, key theoretical issues regarding multirate systems are addressed, including the time-varying nature of the multirate ILC setup. The proposed multirate ILC approach is shown to outperform discrete time ILC in realistic simulation examples.

MSC:

[93C57](#) Sampled-data control/observation systems
[68T05](#) Learning and adaptive systems in artificial intelligence
[93C62](#) Digital control/observation systems

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[learning control](#); [iterative](#); [sampled-data control](#); [sampled signals](#); [optimal control](#)

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References:

- [1] Åström, K.J.; Hagander, P.; Sternby, J., Zeros of sampled systems, *Automatica*, 20, 1, 31-38, (1984) · [Zbl 0542.93047](#)
- [2] Åström, K.J.; Wittenmark, B., *Computed-controlled systems: theory and design*, (1990), Prentice-Hall Englewood Cliffs, NJ, USA
- [3] Bamieh, B., Intersample and finite wordlength effects in sampled-data problems, *IEEE transactions on automatic control*, 48, 4, 639-643, (2003) · [Zbl 1364.93439](#)
- [4] Bamieh, B.; Pearson, J.B.; Francis, B.A.; Tannenbaum, A., A lifting technique for linear periodic systems with applications to sampled-data control, *Systems and control letters*, 17, 2, 79-88, (1991) · [Zbl 0747.93057](#)
- [5] Bien, Z.; Xu, J.-X., *Iterative learning control: analysis, design, integration and applications*, (1998), Kluwer Academic Publishers Norwell, MA, USA
- [6] Böttcher, A.; Silbermann, B., *Introduction to large truncated Toeplitz matrices*, (1999), Springer-Verlag New York, NY, USA · [Zbl 0916.15012](#)
- [7] Bristow, D.A.; Tharayil, M.; Alleyne, A.G., A survey of iterative learning control: A learning-based method for high-performance tracking control, *IEEE control systems magazine*, 26, 3, 96-114, (2006)
- [8] Chen, T.; Francis, B., *Optimal sampled-data control systems*, (1995), Springer London, UK · [Zbl 0847.93040](#)
- [9] Chien, C.-J., On the iterative learning control of sampled-data systems, ()
- [10] Donkers, T., van de Wijdeven, J., & Bosgra, O. Robustness against model uncertainties of norm optimal iterative learning control. In *Proc. 2008 Americ. contr. conf.* (pp. 4561-4566)
- [11] Frueh, J.A.; Phan, M.Q., Linear quadratic optimal learning control (LQL), *International journal of control*, 73, 10, 832-839, (2000) · [Zbl 0995.49018](#)
- [12] Gorinevsky, D., Loop shaping for iterative control of batch processes, *IEEE control systems magazine*, 22, 6, 55-65, (2002)
- [13] Gunnarsson, S.; Norrlöf, M., On the design of ILC algorithms using optimization, *Automatica*, 37, 2011-2016, (2001) · [Zbl 0983.93503](#)
- [14] Hara, S., Tetsuka, M., & Kondo, R. (1990). Ripple attenuation in digital repetitive control systems. In *Proc. 29th conf. dec. contr.* (pp. 1679-1684)
- [15] Ishii, H., & Yamamoto, Y. (1998). Periodic compensation for sampled-data \mathcal{H}_∞ repetitive control. In *Proc. 37th conf. dec. contr.* (pp. 331-336)
- [16] Kailath, T.; Koltracht, I., Matrices with block Toeplitz inverses, *Linear algebra and its applications*, 75, 145-153, (1986) · [Zbl 0586.15004](#)

- [17] Kalman, R.E.; Ho, Y.C.; Narendra, K.S., Contributions of linear dynamical systems, (), 189-213 · [Zbl 0151.13303](#)
- [18] Kannai, Y.; Weiss, G., Approximating signals by fast impulse sampling, *Mathematics of control, signals, and systems*, 6, 2, 166-179, (1993) · [Zbl 0786.93069](#)
- [19] Langari, A., \& Francis, B.A. Sampled-data repetitive control systems. In *\textit{Proc. 13th Americ. contr. conf.}* (pp. 3234-3235)
- [20] LeVoci, P.A., \& Longman, R.W. (2004). Intersample error in discrete time learning and repetitive control. In *\textit{Proc. AIAA/AAS astrodynamics specialist conf. and exhibit}* (pp. 1-24)
- [21] Longman, R.W.; Lo, C.-P., Generalized holds, ripple attenuation, and tracking additional outputs in learning control, *Journal of guidance, control and dynamics*, 20, 6, 1207-1214, (1997) · [Zbl 0906.93032](#)
- [22] Moore, K.L., *Iterative learning control for deterministic systems*, (1993), Springer-Verlag London, UK · [Zbl 0773.93002](#)
- [23] Moore, K.L., *Iterative learning control — an expository overview*, *Applied and computational controls, signal processing, and circuits*, 1, 151-214, (1999) · [Zbl 0955.93500](#)
- [24] Oomen, T., van de Wal, M., \& Bosgra, O. (2007a). Aliasing of resonance phenomena in sampled-data control design: Hazards, modeling, and a solution. In *\textit{Proc. 2007 Americ. contr. conf.}* (pp. 2881-2886)
- [25] Oomen, T.; van de Wal, M.; Bosgra, O., Design framework for high-performance optimal sampled-data control with application to a wafer stage, *International journal of control*, 80, 6, 919-934, (2007) · [Zbl 1124.93017](#)
- [26] Phan, M., \& Longman, R.W. (1988). A mathematical theory of learning control for linear discrete multivariable systems. In *\textit{Proc. AIAA/AAS astrodynamics conf.}* (pp. 740-746)
- [27] Sun, M.; Wang, D., Sampled-data iterative learning control for nonlinear systems with arbitrary relative degree, *Automatica*, 37, 2, 283-289, (2001) · [Zbl 0959.93514](#)
- [28] Vaidyanathan, P.P., *Multirate systems and filter banks*, (1993), Prentice Hall Englewood Cliffs, NJ, USA · [Zbl 0784.93096](#)
- [29] van de Wijdeven, J.; Bosgra, O., Residual vibration suppression using Hankel iterative learning control, *International journal of robust and nonlinear control*, 18, 10, 1034-1051, (2008) · [Zbl 1284.93106](#)
- [30] Xu, J.-X., Lee, T.H., \& Zhang, H.-W. (2005). A multirate iterative learning control scheme. In *\textit{Proc. 2005 int. conf. contr. automat.}* (pp. 403-408)
- [31] Yamamoto, Y., A function space approach to sampled data control systems and tracking problems, *IEEE transactions on automatic control*, 39, 4, 703-713, (1994) · [Zbl 0807.93038](#)
- [32] Zhang, B.; Wang, D.; Ye, Y.; Wang, Y.; Zhou, K., Two-mode ILC with pseudo-downsampled learning in high frequency range, *International journal of control*, 80, 3, 349-362, (2007) · [Zbl 1117.93045](#)
- [33] Zhang, B., Wang, D., Wang, Y., Ye, Y., \& Zhou, K. (2008). Comparison studies on anti-aliasing/anti-imaging filtering and signal extension in multi-rate ILC. In *\textit{IFAC 17th triennial world congress}* (pp. 12468-12473)
- [34] Zhang, B.; Wang, D.; Zhou, K.; Ye, Y.; Wang, Y., Pseudo-downsampled iterative learning control, *International journal of robust and nonlinear control*, 18, 10, 1072-1088, (2008) · [Zbl 1284.93153](#)
- [35] Zhou, K.; Doyle, J.C.; Glover, K., *Robust and optimal control*, (1996), Prentice Hall Upper Saddle River, NJ, USA · [Zbl 0999.49500](#)
- [36] Zimmerman, D.L., Block Toeplitz products of block Toeplitz matrices, *Linear and multilinear algebra*, 25, 3, 185-190, (1989) · [Zbl 0693.15014](#)

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