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[Continued on next page]

(54) Title: ADAPTIVE NONLINEAR MODEL PREDICTIVE CONTROL USING A NEURAL NETWORK AND INPUT SAMPLING

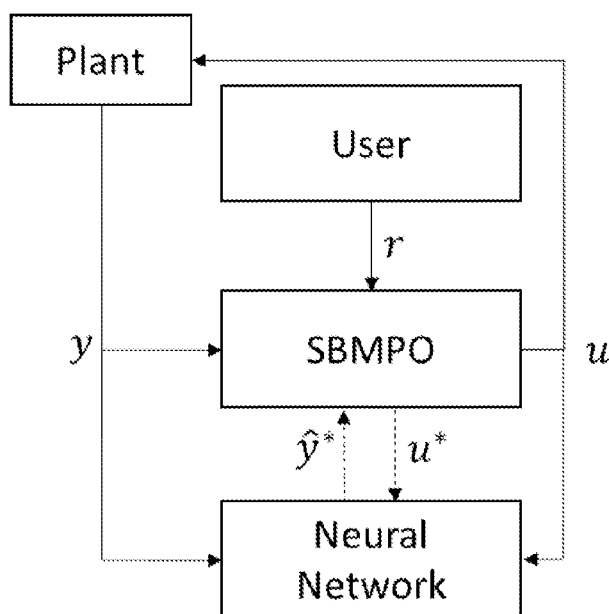


FIG. 1

(57) Abstract: A novel method for adaptive Non-linear Model Predictive Control (NMPC) of multiple input, multiple output (MIMO) systems, called Sampling Based Model Predictive Control (SBMPC) that has the ability to enforce hard constraints on the system inputs and states. However, unlike other NMPC methods, it does not rely on linearizing the system or gradient based optimization. Instead, it discretizes the input space to the model via pseudo-random sampling and feeds the sampled inputs through the nonlinear plant, hence producing a graph for which an optimal path can be found using an efficient graph search method.



TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G05B 13/02 (2015.01)

CPC - B60W 10/06 (2015.10)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - G05B 13/02, G05B 13/04, G05B 23/02, G06F 17/11, G06N 3/02 (2015.01)

CPC - B60W 10/06, F02D 41/0002, F02D 41/0007, F02D 41/0072, F02D 2041/1412, F02D 2041/1433, G05B 13/027, G05B 13/042, G05B 13/048, G05B 19/042, G05B 19/05 (2015.10)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC - 700/1, 700/19, 700/29, 700/30, 700/31, 700/52, 700/53 (Keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Orbit, Google Patents, Google Scholar, Google

Search terms used: nonlinear model predictive control, multiple input multiple output systems, input state, input space

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 20040249483 A1 (WOJSZNIS et al) 09 December 2004 (09.12.2004) entire document	1-20
Y	DUNLAP et al. "Nonlinear model predictive control using sampling and goal-directed optimization." In: 2010 IEEE International Conference on Control Applications (CCA). 10 September 2010 (10.09.2010) Retrieved from <http://static1.squarespace.com/static/542ddec8e4b0158794bd1036/t/542eb1bee4b09ef8489fae51/1412346302337/Nonlinear_model_predictive_control_using_sampling.pdf>, entire document	1-20
Y	WANG et al. "A fast and accurate online self-organizing scheme for parsimonious fuzzy neural networks." In: Neurocomputing. 07 June 2009 (07.06.2009). Retrieved from <https://www.researchgate.net/profile/Ning_Wang42/publication/223175509_A_fast_and_accurate_online_self-organizing_scheme_for_parsimonious_fuzzy_neural_networks/links/0f317537ec48bde33000000.pdf>, entire document	4, 12
A	US 2011/0022193 A1 (PANAITESCU) 27 January 2011 (27.01.2011), entire document	1-20
A	US 2011/0301723 A1 (PEKAR et al) 08 December 2011 (08.12.2011), entire document	1-20
A	US 2009/0143872 A1 (THIELE et al) 04 June 2009 (04.06.2009), entire document	1-20
A	US 2007/0244575 A1 (WOJSZNIS et al) 18 October 2007 (18.10.2007), entire document	1-20

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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