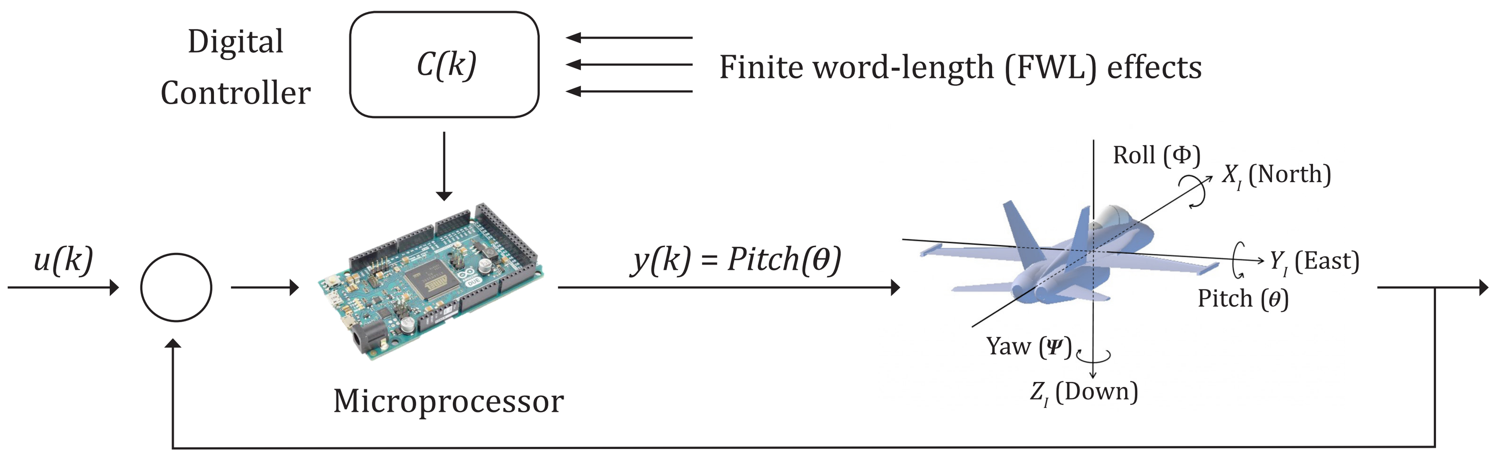
DSSynth: An Automated Digital Controller Synthesis Tool for Physical Plants

Alessandro Abate[1], Iury Bessa[2], Dario Cattaruzza[1], Lennon Chaves[2], Lucas Cordeiro[1,2], Cristina David[1], Pascal Kesseli[1], Daniel Kroening[1] and Elizabeth Polgreen[1]

[1] University of Oxford, Oxford, United Kingdom [2] Federal University of Amazonas, Manaus, Brazi

alessandro.abate@cs.ox.ac.uk, iurybessa@ufam.edu.br, dario.cattaruzza@cs.ox.ac.uk, lennon.correach@gmail.com, lucas.cordeiro@cs.ox.ac.uk, cristina.david@gmail.com, kesseli.pascal@gmail.com, kroening@cs.ox.ac.uk, elizabeth.polgreen@linacre.ox.ac.uk

I Motivation



"...guaranteeing the correctness of cyber-physical systems (CPS) remains an outstanding challenge"

Xi Zheng et al., 2014

"Simulation alone is not sufficient to support verification and validation of CPS"

Sayan Mitra et al., 2013

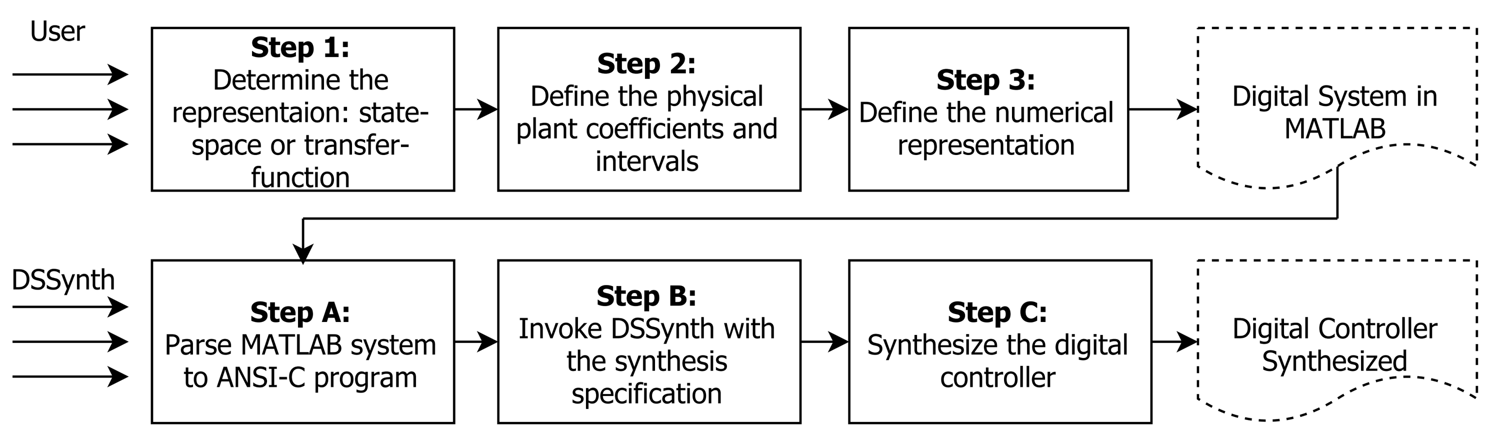
$$\begin{cases} x(k+1) = Ax(k) + Bu(k) \\ y(k) = Cx(k) + Du(k) \end{cases}$$ ← **State-space model**

$$H(z) = \frac{b_0 + b_1 z^{-1} + \ldots + b_m z^{-m}}{a_0 + a_1 z^{-1} + \ldots + a_n z^{-n}}$$ ← **Transfer-function model**

II Approach and Uniqueness

Counter-Example Guided Inductive Synthesis (CEGIS)

Generate sound digital controllers for stability and safety specifications with a very high degree of automation



Step 1

Determine the representation

- State-space model
- Transfer-function model

Step 2

Define the physical plant coefficients and intervals

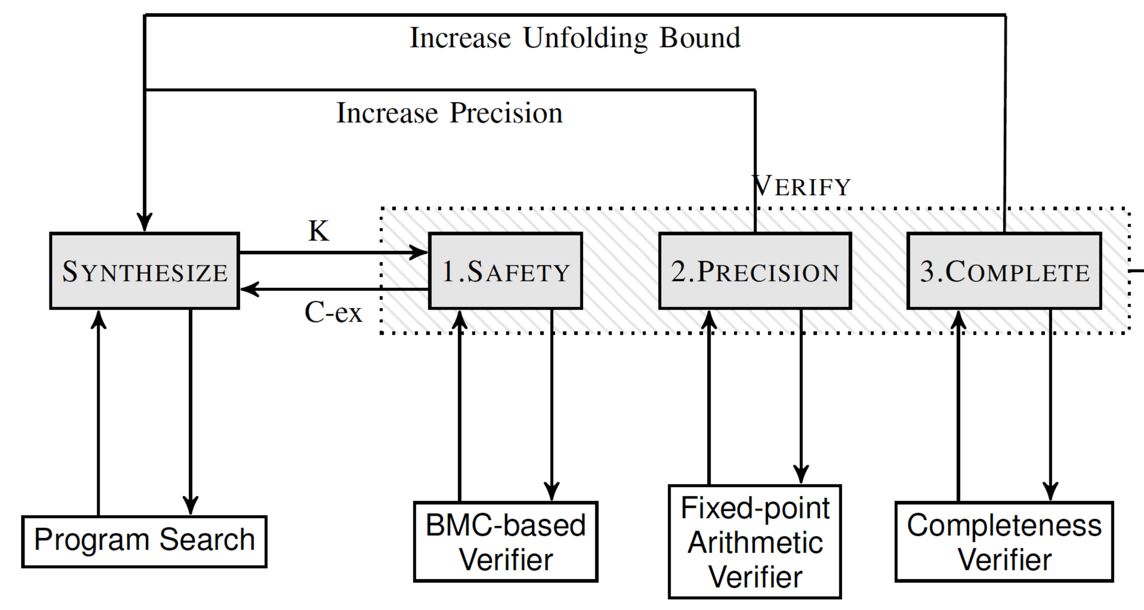
- state-space: matrices A, B, C and D
- transfer-function: coefficients b_0, b_1,..., b_m and a_0, a_1,..., a_n
- uncertainty over the numerator and denominator coefficients

Step 3

Define the numerical representation

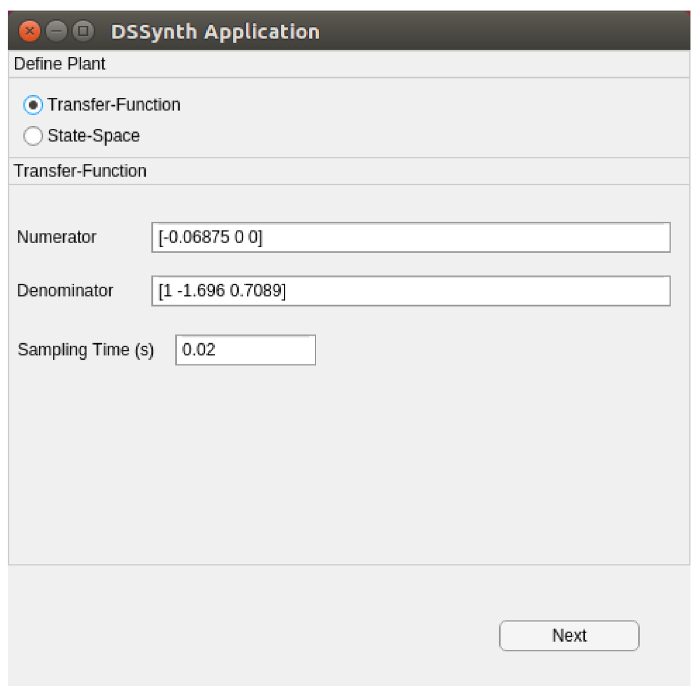
- ***I*** is the integer part
- ***F*** is the fractional part
- dynamical range

III CEGIS for Control Systems

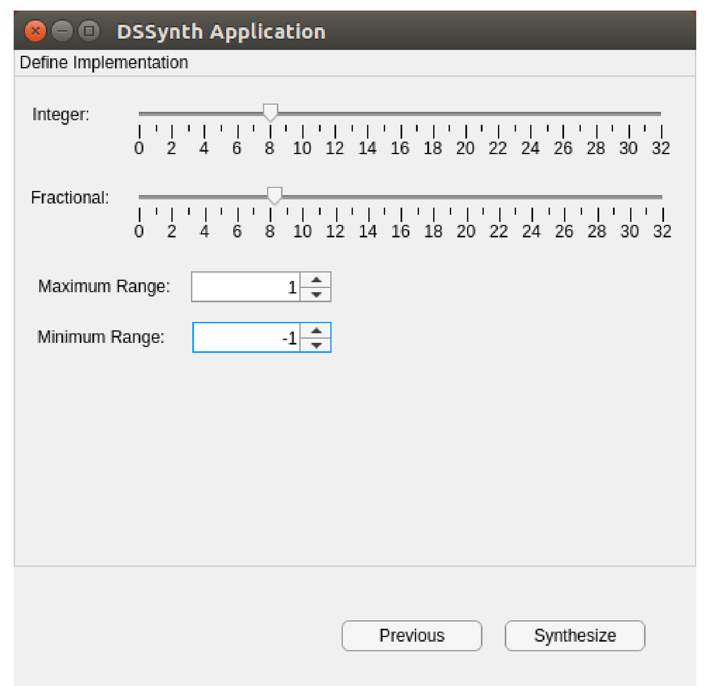


IV DSSynth Toolbox

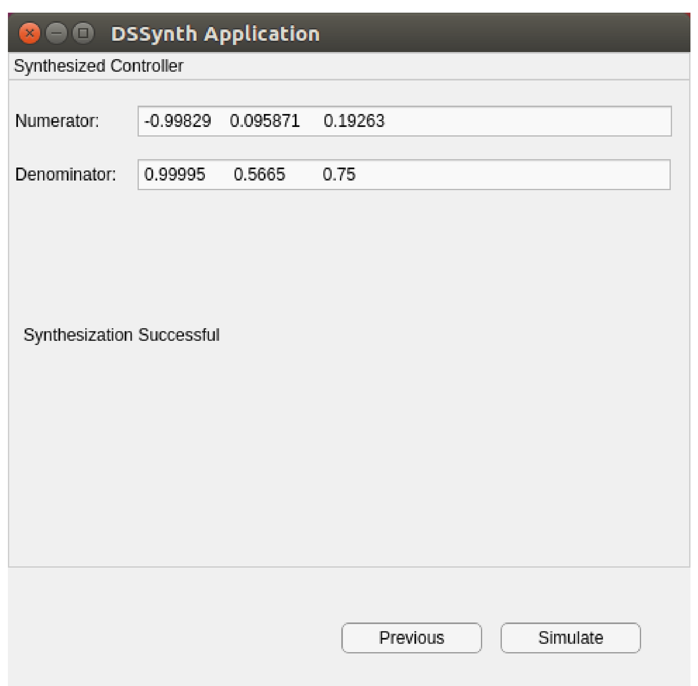
Steps 1 and 2



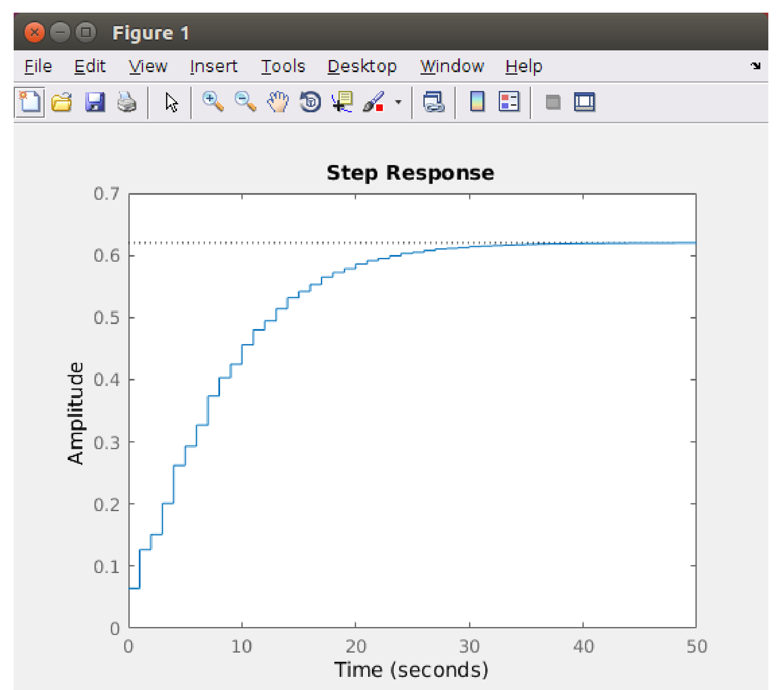
Step 3



Steps A, B and C



Simulation in MATLAB



V Contributions

i. support for transfer-function and state-space representations in closed-loop form;

ii. synthesize different numerical representations and realization forms of the controller using CEGIS;

iii. provide a MATLAB toolbox to synthesize digital controllers while taking into account FWL effects.

As future work:

- DSSynth Toolbox will perform synthesis considering performance requirements;
- we will also pursue the application of CEGIS to further software engineering problems.

Sponsors: UNIVERSITY OF OXFORD; UNIVERSIDADE FEDERAL DO AMAZONAS

For further information, publications, and downloads, see: http://dsverifier.org/dsverifier/dssynth-toolbox/