University of BRISTOL

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Stuff going wrong

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Week's work

- Finished draft of conference paper
  - Too long
- Worked on splines in CBC
  - Doesn't work
- Started re-writing conference paper
  - No splines discretisation
  - Struggling to motivate why the work is valuable

Paper

- Abstract focuses on cleaning noise from signals with surrogate modelling
- Paper draft 1 covers surrogate filtering, and splines discretisation

Issues:

- Paper is too long
  - 17 pages, instead of 10
  - Could trim it, but can't trim 7 pages out without removing key content
- Splines doesn't work
  - I don't want to publish about splines until I know they do what I claim
- Don't have enough time to both trim paper, and fix splines

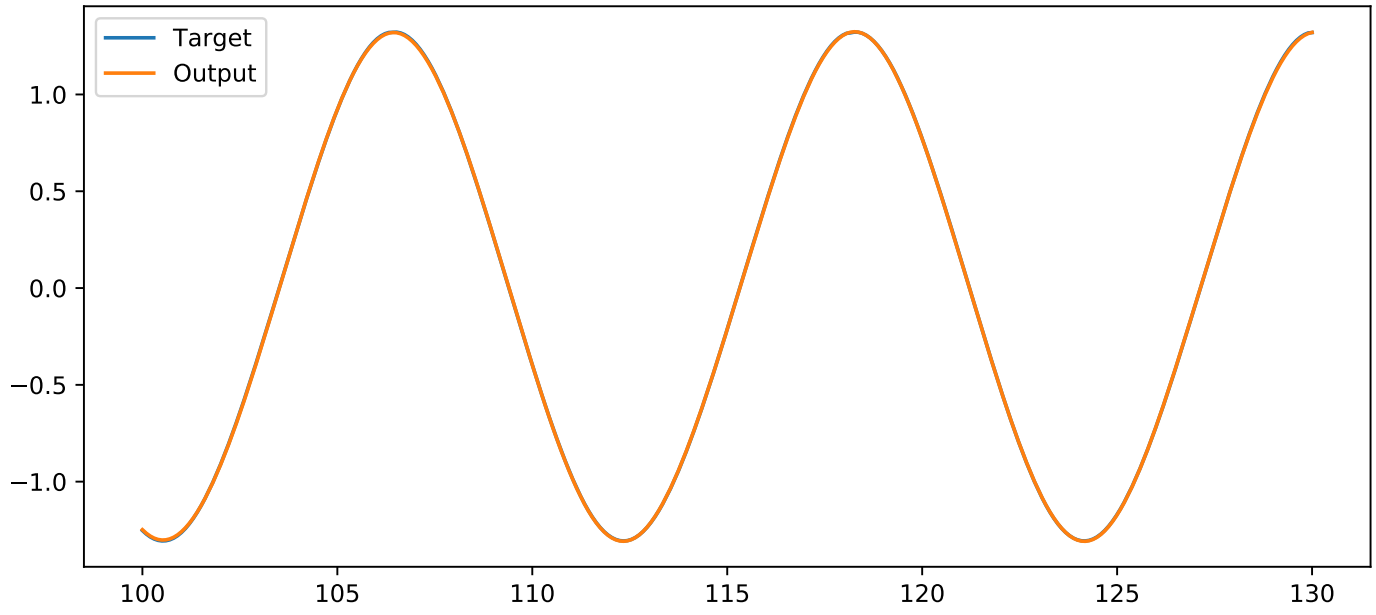
Proposed plan

- Remove discretisation from paper
  - Make paper all about cleaning signals up with surrogates, as discussed in abstract
  - Most realistic goal for getting paper done by deadline
  - Issue: I'm not convinced surrogates are very useful
- Try to get splines to work
  - Write separate conference paper on splines discretisation?
  - Will have the time to demonstrate the method working

Splines in CBC

- Took working Fourier/Duffing, substituted Fourier for splines
  - Doesn't work
- IO-Map method
  - IO-map maps control-target to system output
  - Fixed-point of IO-map means control target = system output
  - Proportional control means fixed-points are noninvasive
- Continuation procedure solves for input = output

Step 1



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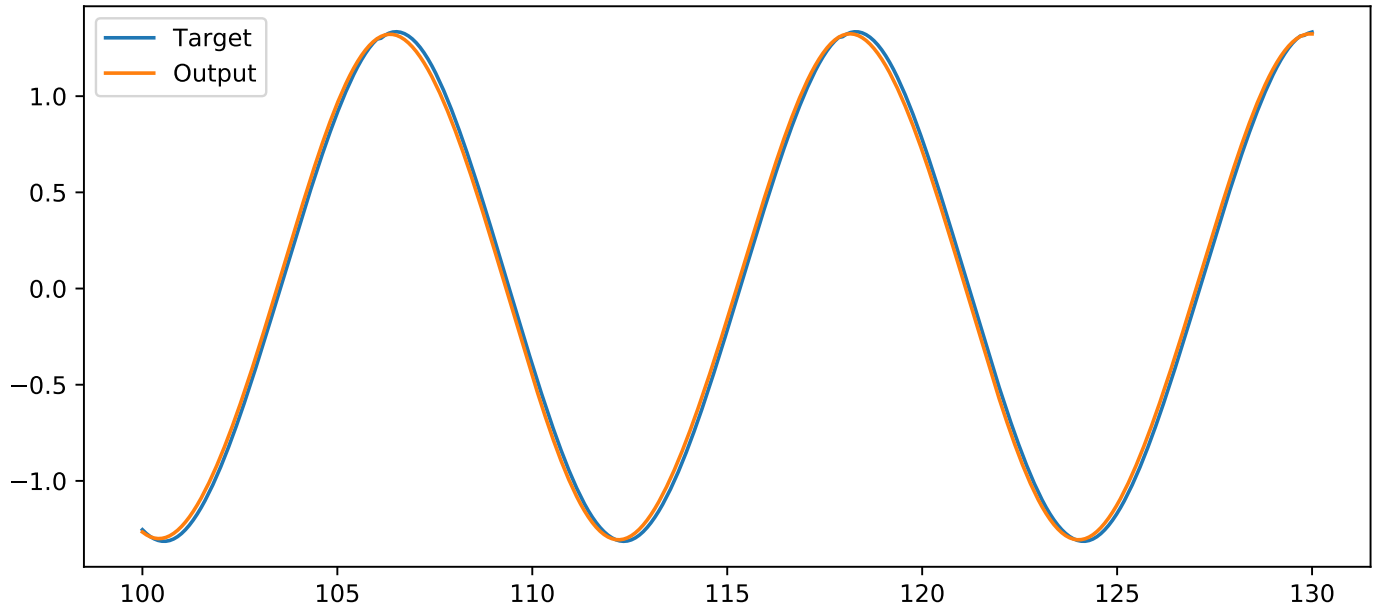

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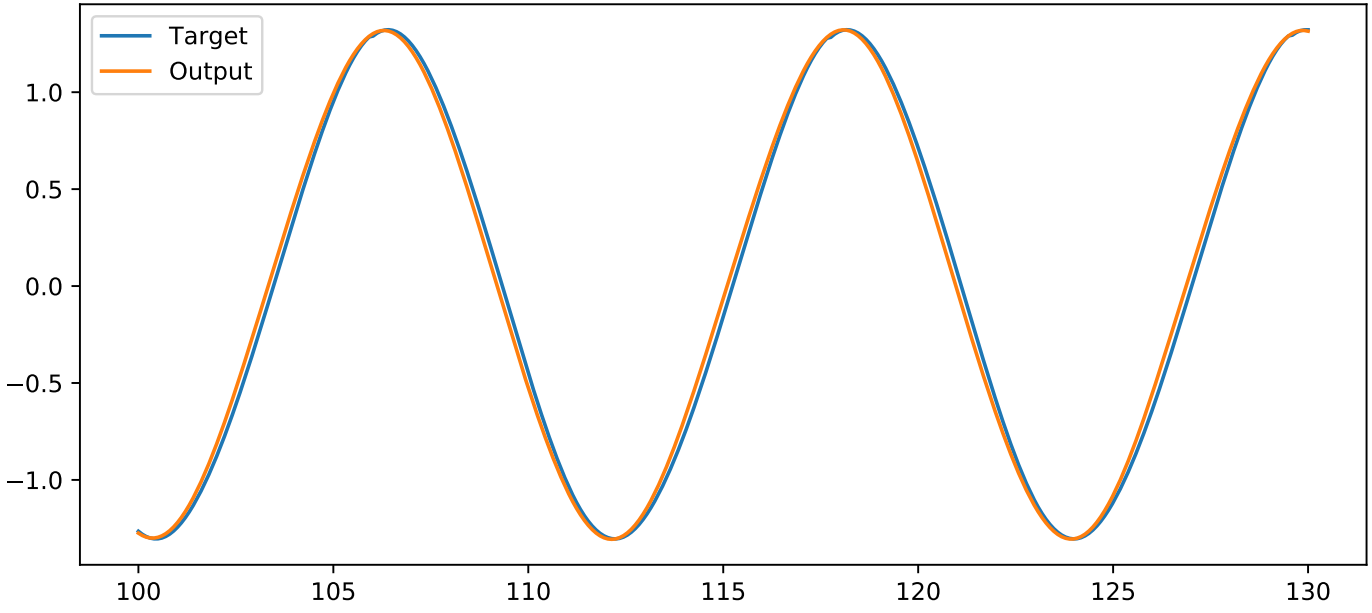

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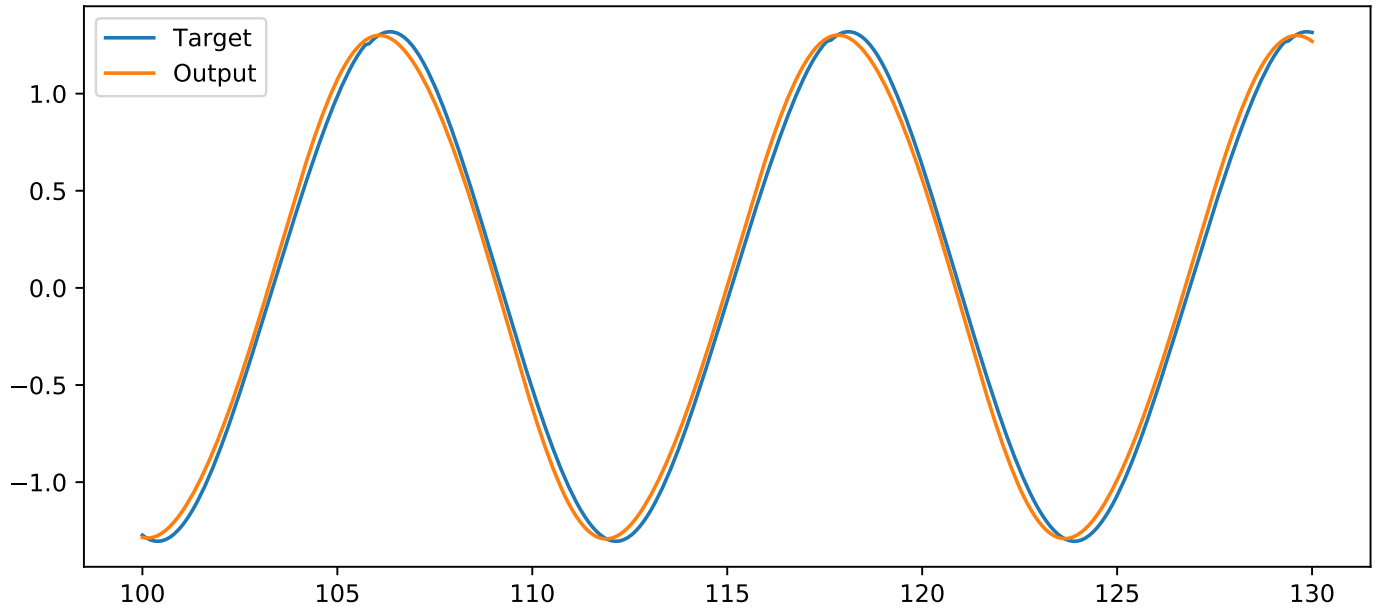

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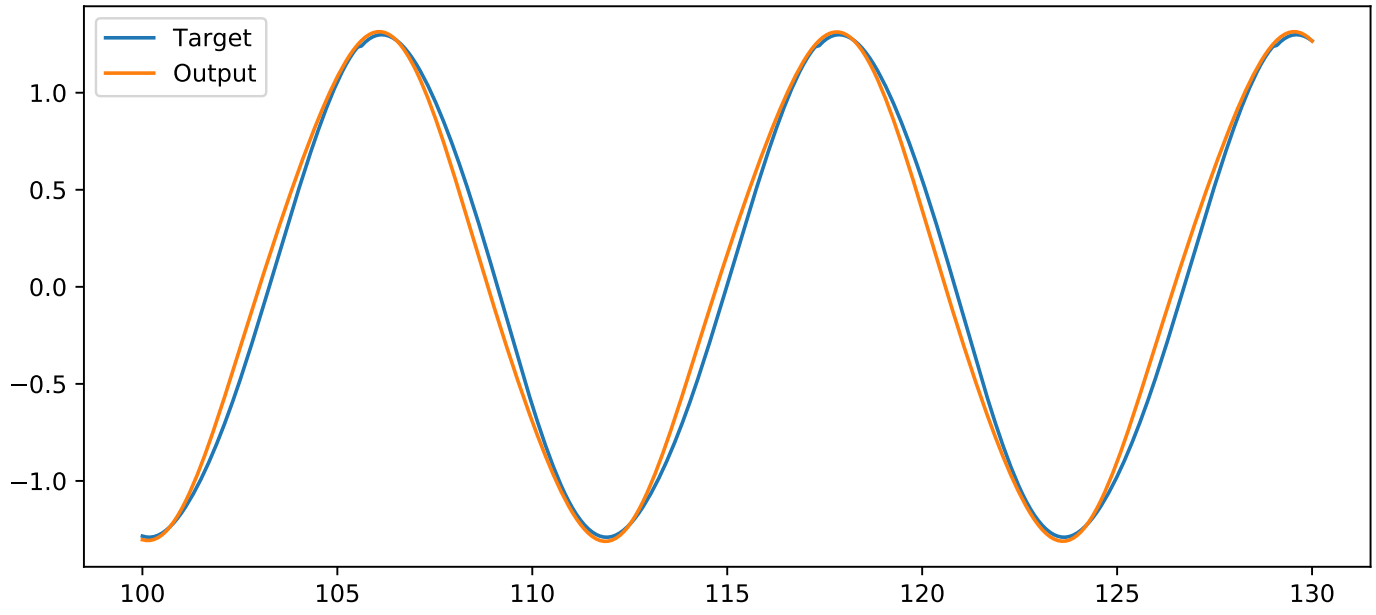

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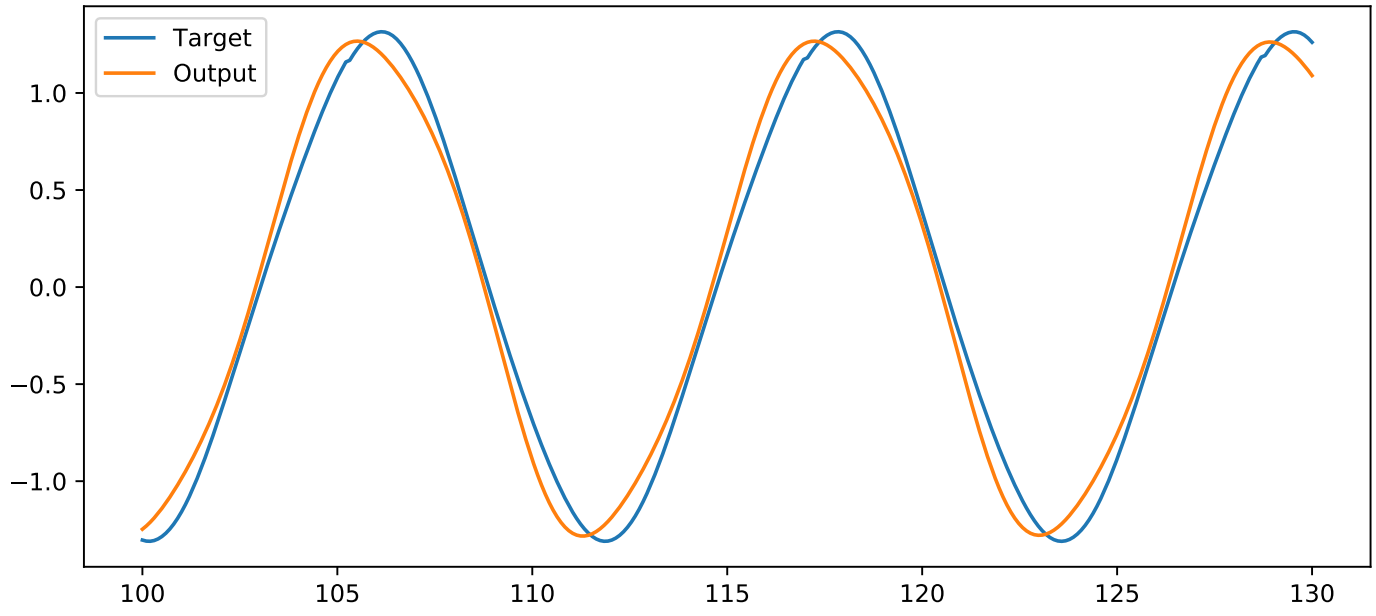

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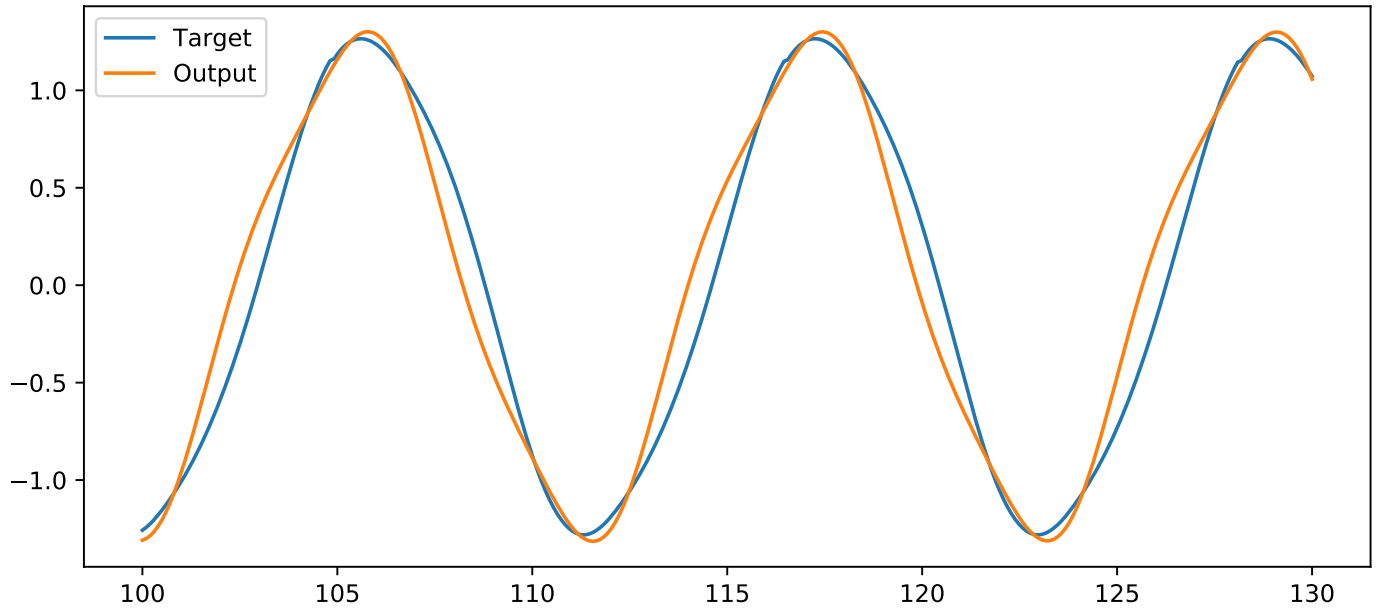

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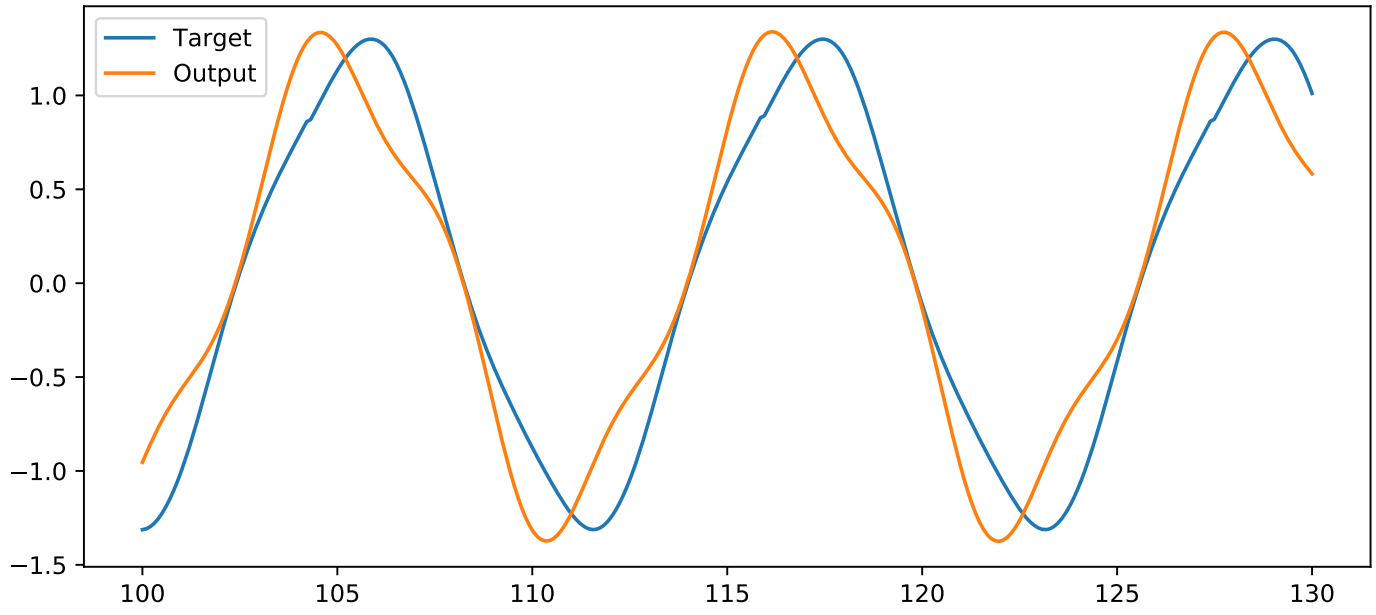
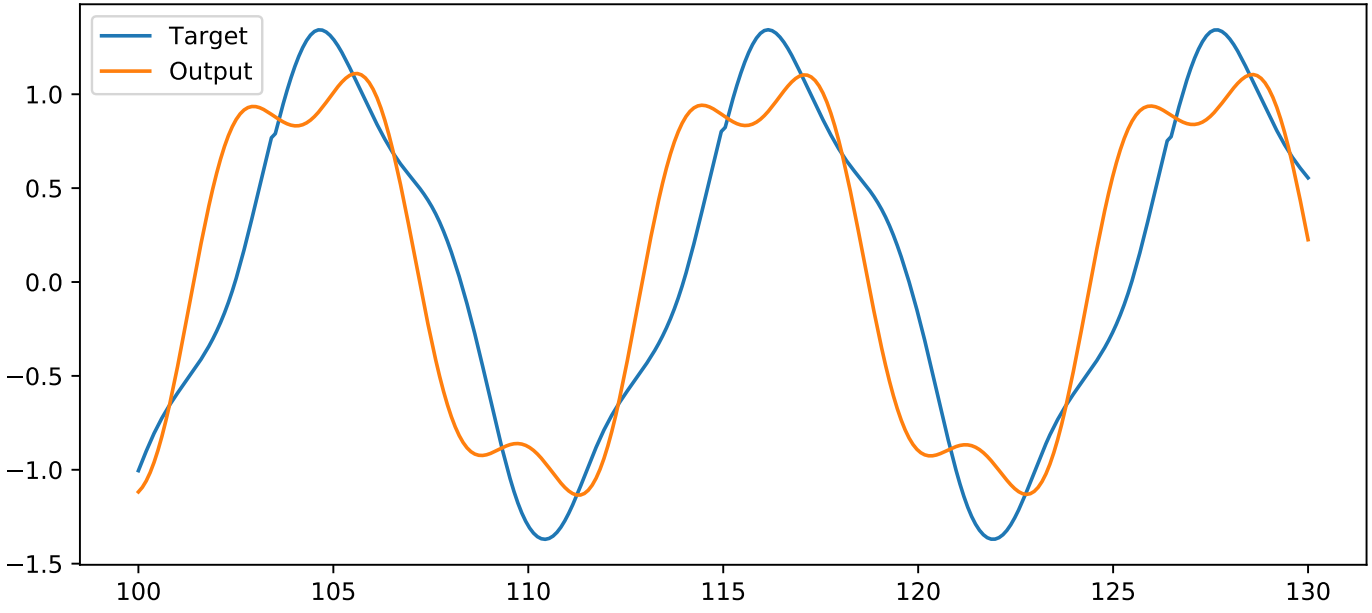


Step 9



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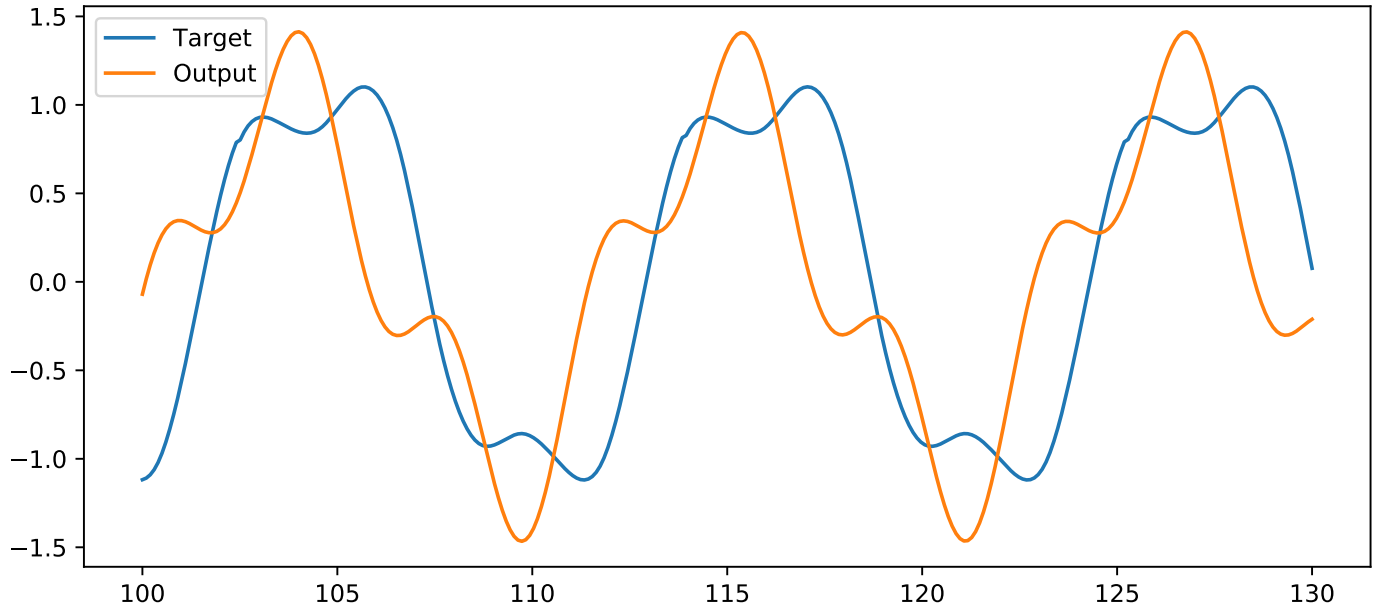


Setup

- $K_p = 1$
  - Worked for Fourier/Duffing
  - Increasing causes CBC to fail faster
- Solver = Levenberg-Marquardt algo
  - Most numerically stable; others fail within one or two steps
- Evenly-spaced knots
  - Optimized knots fail even faster
- 10 knots
  - No change using more / fewer knots
- Default solver tolerance
  - Lower = faster failure

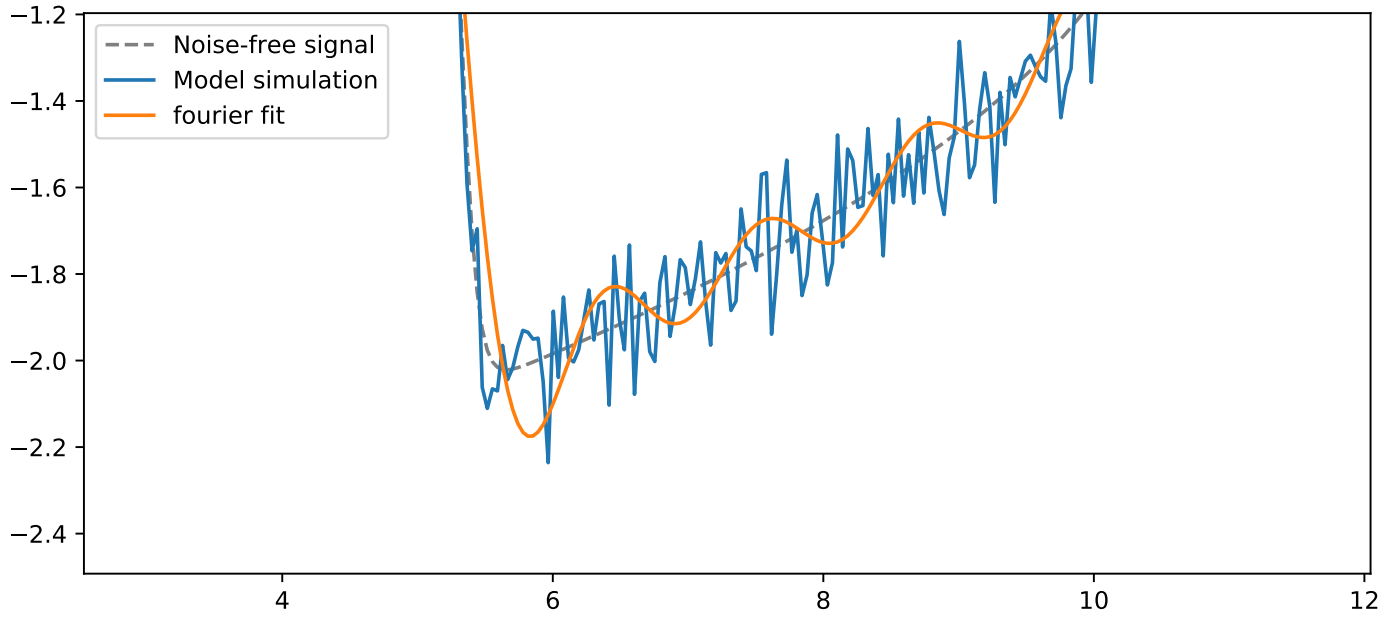
No idea why things aren't working

Surrogates paper

- Using few Fourier harmonics doesn't fit 'difficult' signals
- Using many Fourier harmonics doesn't average out noise
- Surrogates can be used to filter out noise, for better discretisation
  - No phase shift or signal distortion

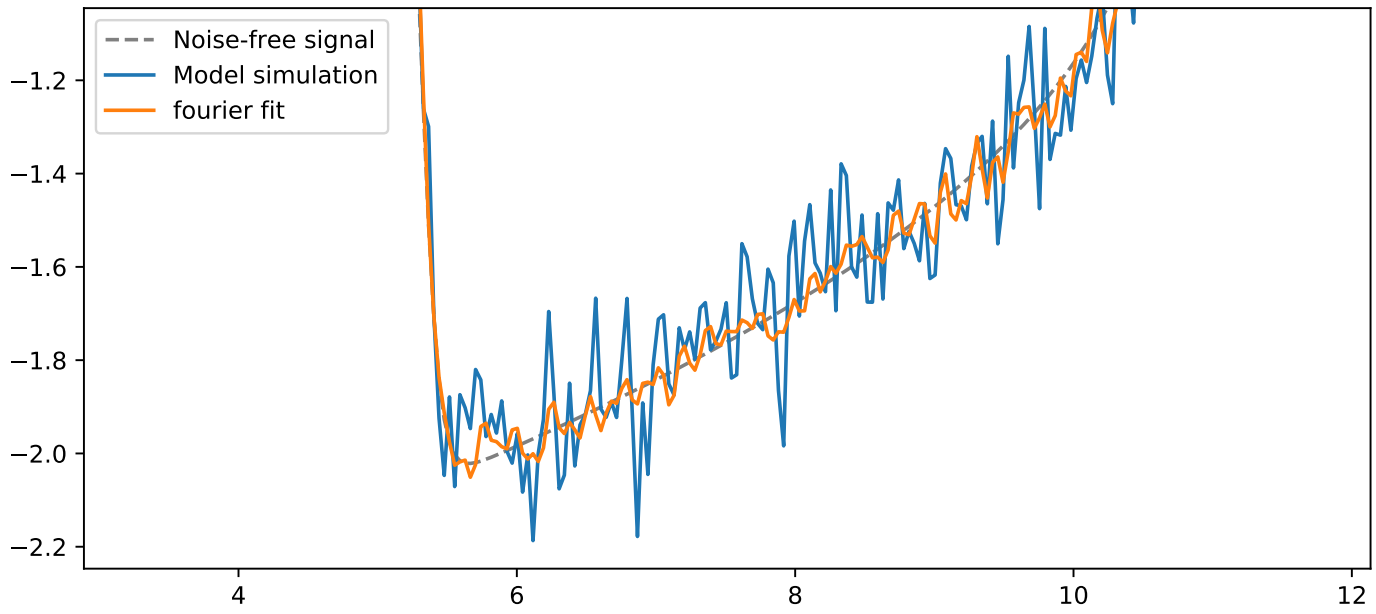
Surrogates

Direct Fourier; too few harmonics to fully fit the signal



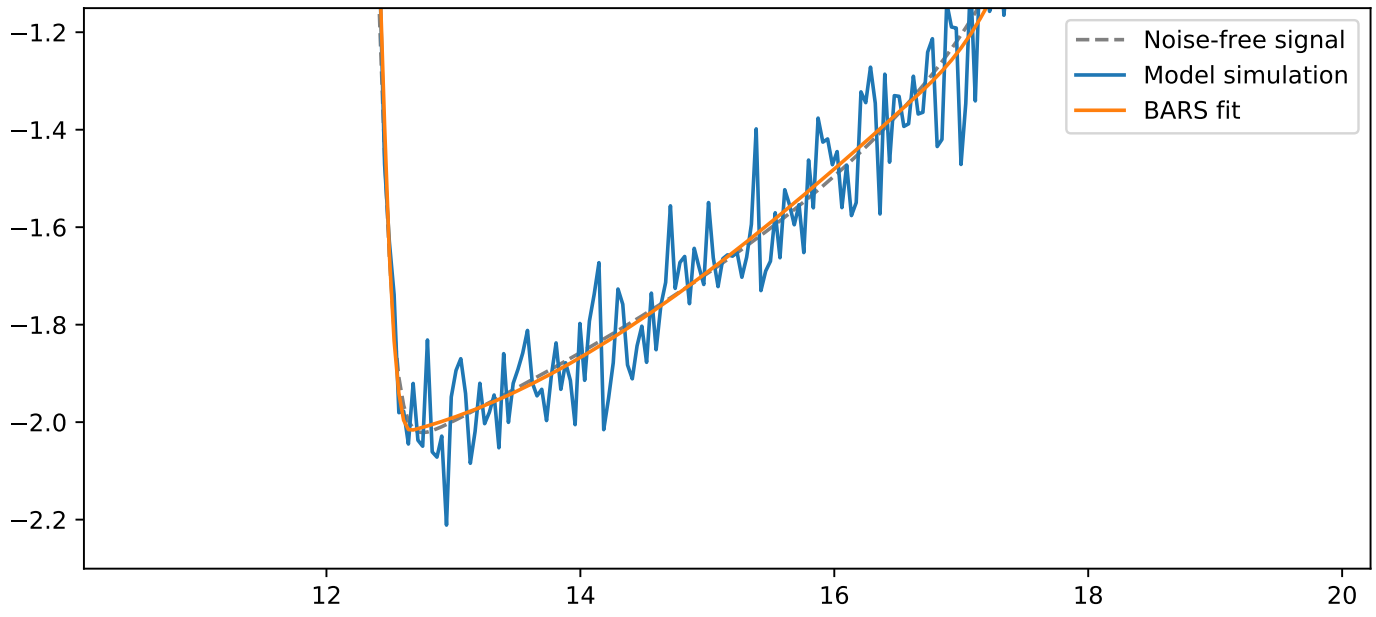
Surrogates

Direct Fourier; enough harmonics to fit the signal, but also noise



Surrogates

Splines surrogate model; noise is removed, so Fourier can be fitted accurately

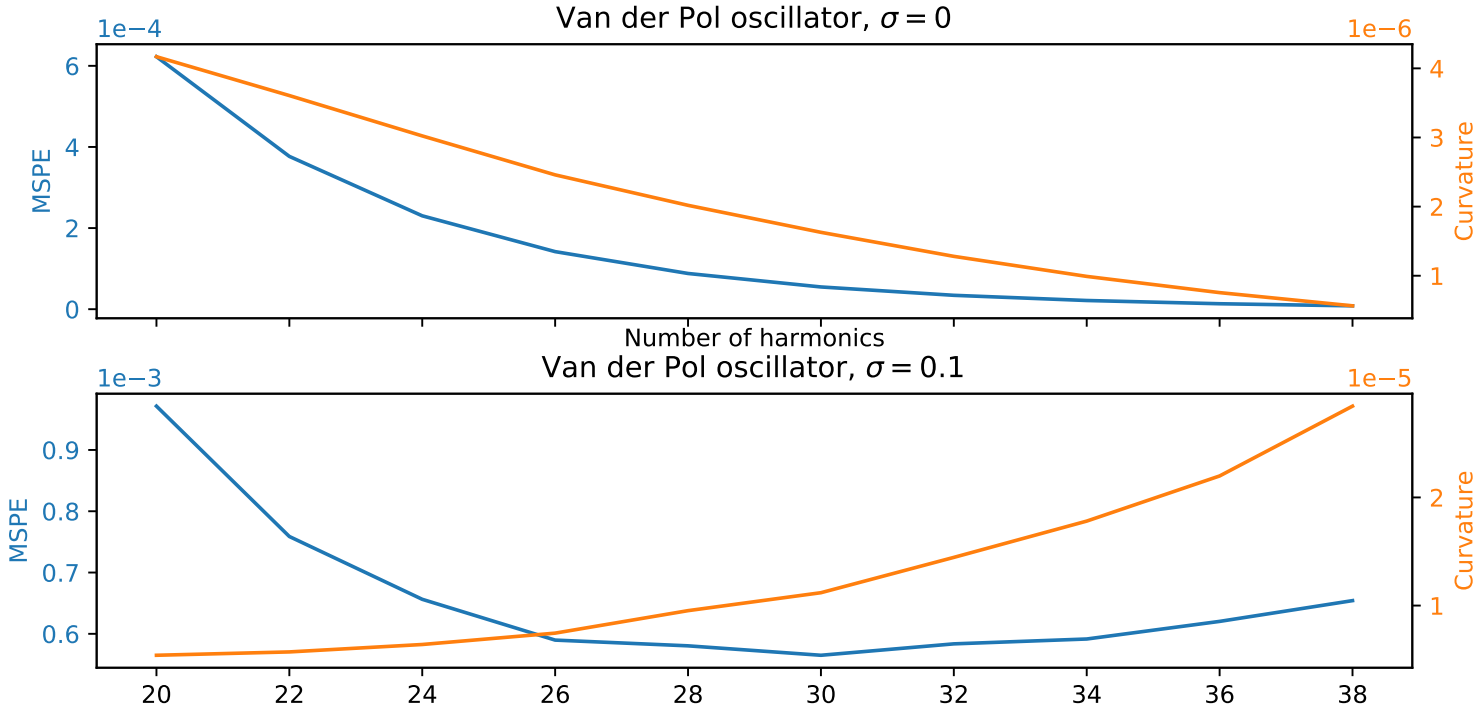


Choosing number of harmonics

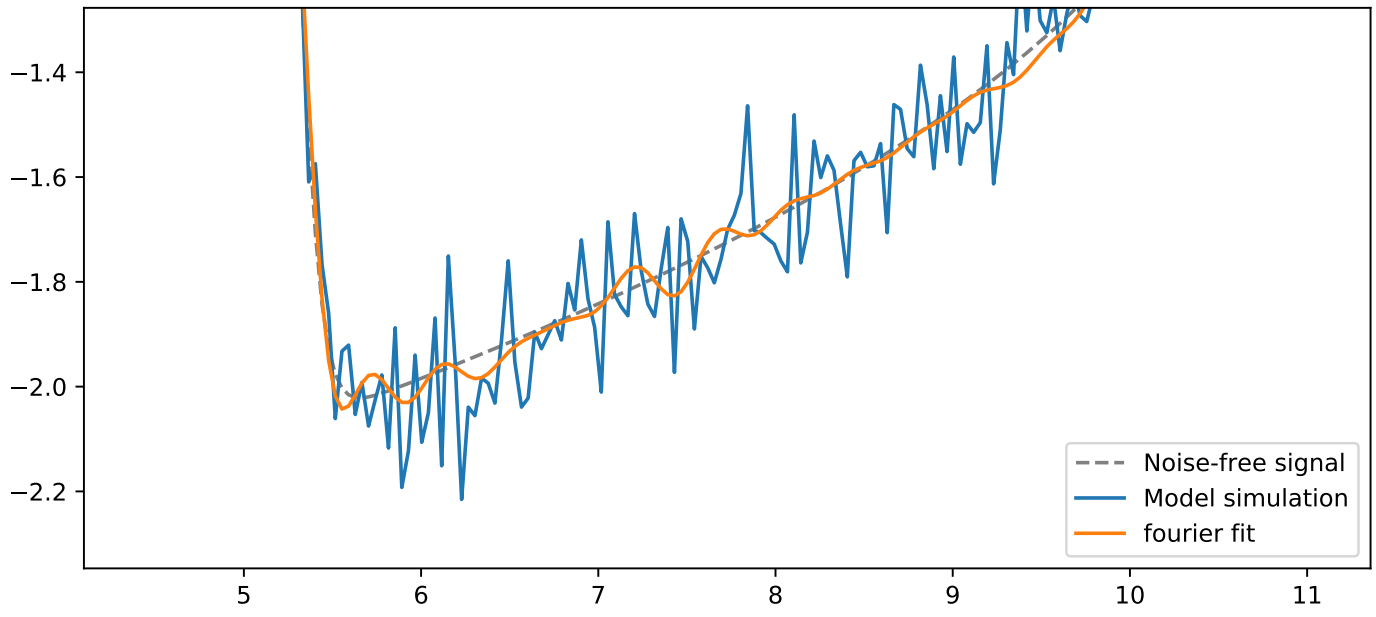
Idea: quantify model noisiness by a curvature measure

- $c_i = h^{-2}(x_{i-1} - 2x_i + x_{i+1})$
  - Finite differences pointwise-curvature approximation
- Majority of curvatures *should* be small
  - Median pointwise-curvature is a good statistic for model noisiness
- How do curvature, error change with number of harmonics?
  - Low curvature, high MSPE = too few harmonics
  - High curvature, low MSPE = too many harmonics
  - Optimal harmonics = low curvature, low MSPE

Finding the sweetspot



Good enough?


−1.4
−1.6
−1.8
−2.0
−2.2
5
6
7
8
9
10
11
Noise-free signal
Model simulation
fourier fit

Issues

- Surrogates do clean up the signal, but is the improvement really enough to be worthwhile?
  - According to MSPE, surrogates and Fourier perform equally well
- Is anyone really going to harmonically force a multiple-timescale system?
  - Fourier filters effectively when there's few harmonics, so surrogate filtering becomes unnecessary
  - Surrogate filtering appears to be useful when we have many harmonics, but in these cases we'd use a more efficient discretisation
  - The splines discretisors are noise-robust, so surrogates become unnecessary

Are surrogates worth publishing?

- Fixes a problem that doesn't really exist
  - Not useful for few-harmonics-signals, as Fourier filters noise out
  - Not useful for many-harmonics-signals, as we would do better using a novel discretisation
- Even when surrogates do work, the resulting improvement is minimal
- Hard to write about surrogates being useful when prediction errors are worse than raw Fourier
  - Hard to quantitatively demonstrate that surrogates do anything

Next steps

- Keep (re)writing conference paper?
  - My opinion: cancel it, spend the time on discretisation

- Keep working on splines, once paper is done
  - Try to understand and fix their lack of numerical stability
  - Demonstrate on *in silico* CBC
    - IO map method and ‘other’ method