NMFk example: Mapping variables

A problem demonstrating how **NMFk** can be applied to learn mapping between variables.

The test problem is related to predicting pressure transients observed in wells based on various attributes (e.g., well-logs, fracking stages, proppant mass, etc.) associated with the well construction.

The machine-lerning problem described here relates to clasical history matching problems.

If **NMFk** is not installed, first execute `import Pkg; Pkg.add("NMFk"); Pkg.add("Mads")`.

We start by loading the necessary Julia modules:

In [1]:
```
import NMFk
```

Unable to load WebIO. Please make sure WebIO works for your Jupyter client. For troubleshooting, please see [the WebIO/IJulia documentation (https://juliagizmos.github.io/WebIO.jl/latest/providers/ijulia/)](https://juliagizmos.github.io/WebIO.jl/latest/providers/ijulia/).

```
┌ Info: Installing pyqt package to avoid buggy tkagg backend.
└ @ PyPlot /Users/vvv/.julia/packages/PyPlot/XHEG0/src/init.jl:118
```

In [2]:
```
import Mads
```

In [3]:
```
import Statistics
```

Load test matrices `A`, `B`, `X`, `Y` and `Z` that will be applied for the ML analyses presented below:

In [5]:
```
A = permutedims([0.168427       0.049914       0.031383       0.020747
       0.959030       0.203276       0.095674       0.043699       0.00
       0.208403       0.064995       0.039014       0.019713       0.00
       0.948621       0.217649       0.101904       0.049093       0.02

B = permutedims([0.654060       0.142989       0.043485       0.000000
       1.000000       0.090943       0.048150       0.018898       0.00
       0.076188       0.020636       0.011489       0.006166       0.00
       0.378206       0.098391       0.041083       0.009261       0.00
       0.055413       0.021730       0.010460       0.004788       0.00

X = permutedims([0.500       0.002       0.667       0.40
       0.800       0.200       0.667       0.76
       0.800       0.100       0.400       0.80
       0.600       0.010       1.000       0.40])

Y = permutedims([1.000       0.600       0.267       1.00
       0.700       0.020       0.333       0.60
       1.000       0.020       0.200       0.72
       0.700       1.000       0.233       0.60
       1.000       0.060       0.133       0.80])

Z = permutedims([0.800       0.400       0.100       0.60]);
```

`A` : pressure transients over time observed in a group of 5 wells

`B` : pressure transients over time observed in a group of 4 wells

`X` : 4 attributes representing well properties of the group of 4 wells

`Y` : 4 attributes representing well properties of the group of 5 wells

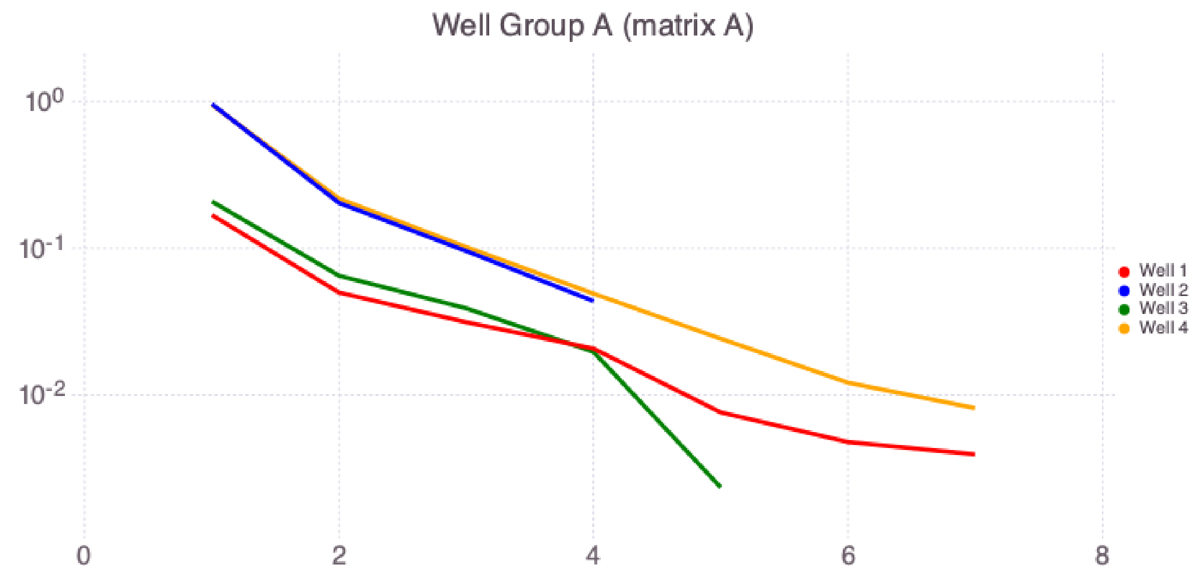
`Z` : 4 attributes representing well properties of a new well which does not have any transient production data observed yet

Pressure matrix `A` is associated with attribute matrix `Y` .

Pressure matrix `B` is associated with attribute matrix `X` .

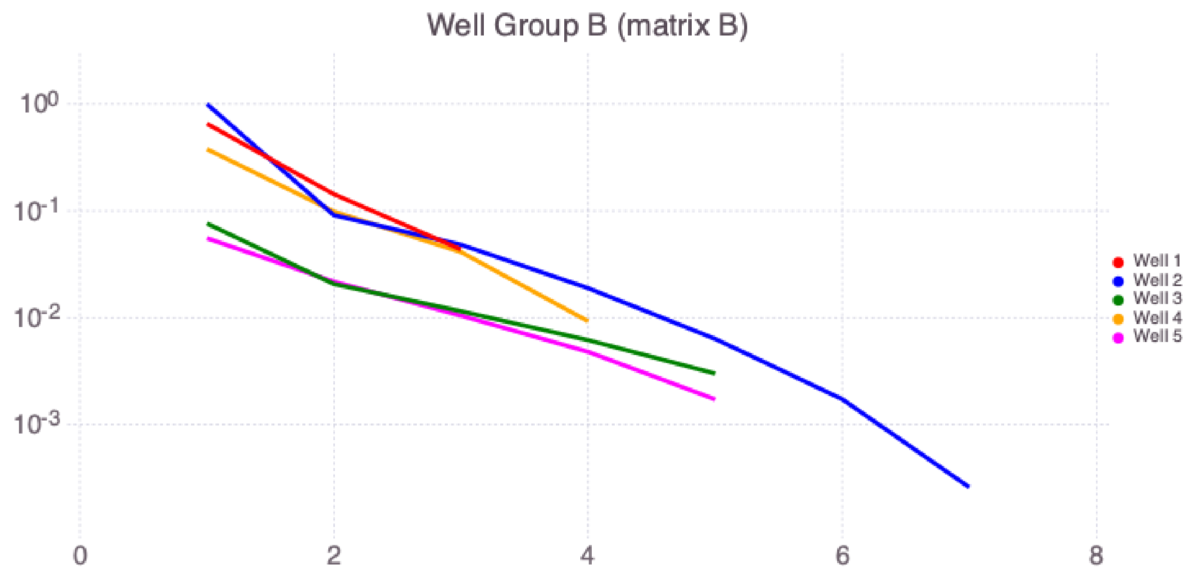
Pressure transients over time observed in the group of 5 wells (matrix `A`) are:

In [6]:
```
Mads.plotseries(A; name="Well", logy=true, title="Well Group A (matrix A)")
```



Pressure transients over time observed in the group of 4 wells (matrix `B`) are:

In [7]:
```
Mads.plotseries(B; name="Well", logy=true, title="Well Group B (matrix B)")
```



Well attributes for the group of 5 wells (matrix `Y`) are:

In [27]:
```
NMFk.plotmatrix(Y; title="Attribute matrix Y (Well Group A)", xticks=["W$i"
```

Out[27]: W1 W2 W3 W4 W5 1.0 0.5 0.0 h,j,k,l,arrows,drag to pan i,o,+,-,scroll,shift-drag to zoom r,dbl-click to reset c for coordinates ? for help ? Attribute 1 Attribute 2 Attribute 3 Attribute 4 Attribute matrix Y (Well Group A)

Well attributes for the group of 4 wells (matrix X) are:

In [28]:
```
NMFk.plotmatrix(X; title="Attribute matrix X (Well Group B)", xticks=["W$i"
```

Out[28]: W1 W2 W3 W4 1.0 0.5 0.0 h,j,k,l,arrows,drag to pan i,o,+,-,scroll,shift-drag to zoom r,dbl-click to reset c for coordinates ? for help ? Attribute 1 Attribute 2 Attribute 3 Attribute 4 Attribute matrix X (Well Group B)

We learn how the well attributes associated with the 2 well groups are related.

We achieve this by discovering how the `X` and `Y` matrices are mapped.

After that we can apply the discovered mapping betweent the `X` and `Y` matrices (i.e., well attributes) to predict the transients.

The ML analyses is performed as follows:

In [10]:
```
W, H, of, sil, aic = NMFk.mapping(X, Y, A, B; method=:ipopt, save=false);
```

```
┌ Info: Mapping matrix size: 4 x 5
└ @ NMFk /Users/vvv/.julia/dev/NMFk/src/NMFkMapping.jl:51
```

The extracted mapping betweenn the `X` and `Y` matrices is encoded in `H`.

We use now the mapping `H` and known transients of wells in group `A` (matrix `A`) to predict transients of the well in group `B` .

In this case, we assume that none of the transinets of well in group are known; this is completely blind prediction.

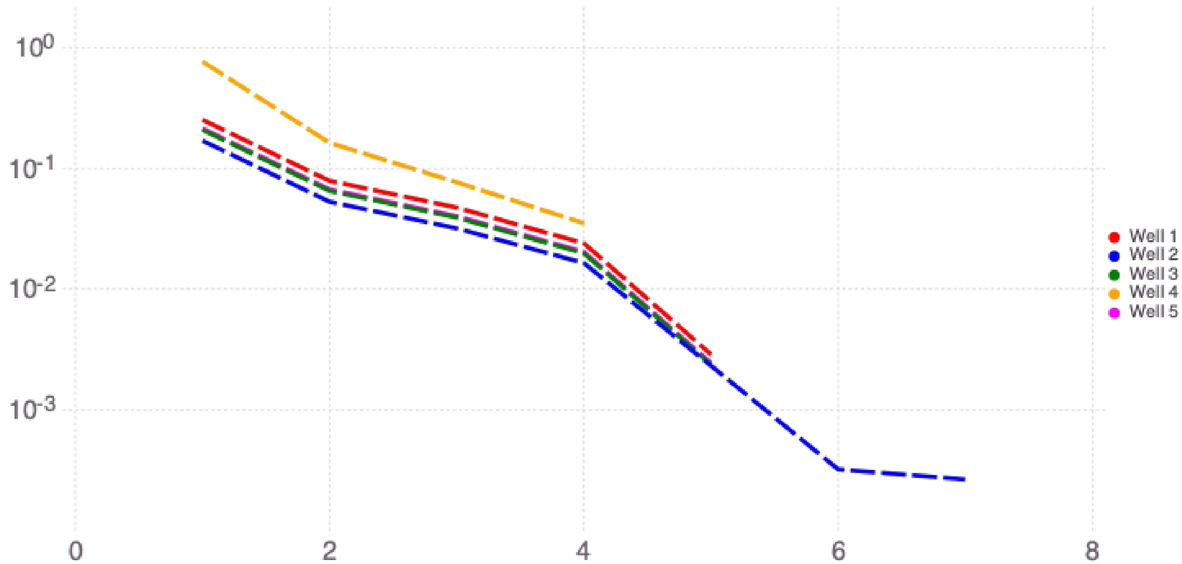
The prediction error is:

In [11]:
```
NMFk.normnan(B .- (A * H))
```

Out[11]: 1.032261490452482

Blind predictions of the transients for the 5 wells (Group `B`) based on the transinets of the 4 wells (Group `A`) are:

In [14]:
```
Mads.plotseries(A * H; logy=true, name="Well", linestyle=:dash)
```



Blind predictions of the transients for the 5 wells (dashed lines) are compared against the true values (solid lines):

In [18]:
```
series(A * H; linestyle=:dash, name="Well (est.)", logy=true, gl=Mads.plotse
```