Brief GST report for MyDataset

Wednesday 4th October, 2017

1 Overview

This report presents a brief gate-set tomography (GST) analysis of a dataset called "MyDataset". It is intended for folks who are already familiar with GST output tables and plots. If this isn't you, you should have GST generate a "full report" which give much more detail about what GST is and what the results in this "brief report" mean.

2 Goodness-of-model

Table 1 shows how well GST was able to fit you data through its iterations.

L	$2\Delta\log(\mathcal{L})$	k	$2\Delta\log(\mathcal{L})-k$	$\sqrt{2k}$	N_σ	N_s	N_p	Rating
0	105.41	99	6.4144	14.071	0.46	142	43	★★★★★
1	105.41	99	6.4144	14.071	0.46	142	43	★★★★★
2	171.46	160	11.463	17.889	0.64	203	43	★★★★★
4	248.79	230	18.792	21.448	0.88	273	43	★★★★★
8	762.51	762	0.5129	39.038	0.01	805	43	★★★★★
16	1332.3	1301	31.284	51.01	0.61	1344	43	★★★★★
32	1837.8	1840	-2.211	60.663	-0.04	1883	43	★★★★★

Table 1: **Comparison between the computed and expected $2\Delta\log\mathcal{L}$ for different values of L.** N_S and N_p are the number of gate strings and parameters, respectively. $2\Delta\log\mathcal{L}$ is expected to lie within $[k-\sqrt{2k}, k+\sqrt{2k}]$ where $k = N_s - N_p$. P is the p-value derived from a χ^2_k distribution (i.e. when $P <$ some threshold like 0.05 there is grounds for rejecting the GST fit). The rating from 1 to 5 stars gives a very crude indication of goodness of fit as explained in the text.

3 Gateset Estimates

Below is a collection of GST's primary result tables, ordered in what we think is a natural way. These tables all pertain to the best-estimate gateset, that is, the one corresponding to the final iteration of the GST algorithm.

3.1 Derived Quantities

Gate	Process Infidelity	1/2 Trace Distance	1/2 $\Diamond$-Norm
Gx	0.0376 $\pm$0.0006	0.0376 $\pm$0.0006	–
Gy	0.0377 $\pm$0.0007	0.0377 $\pm$0.0007	–
Gu	0.0373 $\pm$0.0003	0.0373 $\pm$0.0003	–
Gv	0.0375 $\pm$0.0003	0.0375 $\pm$0.0003	–

Gate	Error Generator
Gx	$\begin{pmatrix} 0 & 0 & 0 & 0 \\ -0.0002 & -0.0512 & -0.0006 & -0.0001 \\ 0.0003 & 0.0009 & -0.0517 & 0.0006 \\ 5 \times 10^{-5} & 0.0005 & 0.0005 & -0.0517 \end{pmatrix}$
Gy	$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0.0001 & -0.0517 & -0.0016 & -0.0011 \\ -0.0005 & 0.0007 & -0.0512 & 0.0003 \\ 0.0004 & 0.0023 & -0.0013 & -0.0517 \end{pmatrix}$
Gu	$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0.0001 & -0.0516 & -0.0007 & -0.0008 \\ -0.0002 & -0.0003 & -0.0513 & 0.0008 \\ 9 \times 10^{-6} & -0.0004 & 0.0003 & -0.0503 \end{pmatrix}$
Gv	$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0.0002 & -0.0517 & 0.0012 & 0.0003 \\ 0.0001 & -0.0005 & -0.0511 & -0.001 \\ -0.0001 & -0.0009 & 0.0009 & -0.0512 \end{pmatrix}$

Table 2: **Comparison of GST estimated gates to target gates**. This table presents, for each of the gates, three different measures of distance or discrepancy from the GST estimate to the ideal target operation. See text for more detail. The second table lists the "Error Generator" for each gate, which is the Lindbladian $\mathbb{L}$ that describes *how* the gate is failing to match the target. This error generator is defined by the equation $\hat{G} = G_{\text{target}} e^{\mathbb{L}}$.

Gate	Eigenvalues			Fixed pt	Rotn. axis	Diag. decay	Off-diag. decay
Gx	$0.9496e^{i1.571}$ $0.9496e^{-i1.571}$ 1 0.9501	$\pm$	$0.0018e^{i0.530}$ $0.0018e^{i0.530}$ 0 0.0017	1 -0.0044 -0.0002 0.0001	0 1 -0.0007 0.0002	0.0499 ± 0.0017	0.0504 ± 0.0009
Gy	1 0.9501 $0.9496e^{i1.569}$ $0.9496e^{-i1.569}$	$\pm$	0 0.0019 $0.0017e^{i0.637}$ $0.0017e^{i0.637}$	0.9999 0.0002 -0.0091 -0.0003	0 -0.0001 -1 -0.0014	0.0499 ± 0.0019	0.0504 ± 0.001
Gu	1 0.9498 -0.9498 -0.9511			X	X	X	X
Gv	1 0.9502 $0.9498e^{i3.141}$ $0.9498e^{-i3.141}$	$\pm$	0 0.0008 $0.001e^{i1.042}$ $0.001e^{i1.042}$	1 -0.0001 0.001 0.0001	0 -0.0006 1 -0.0005	0.0498 ± 0.0008	0.0502 ± 0.0005

Gate	Angle	Angle between Rotation Axes			
		Gx	Gy	Gu	Gv
Gx	$(0.5$ $\pm 0.0005)\pi$		$(0.4998$ $\pm 0.0006)\pi$	–	$(0.5004$ $\pm 0.0005)\pi$
Gy	$(0.4995$ $\pm 0.0004)\pi$	$(0.4998$ $\pm 0.0006)\pi$		–	$(0.9994$ $\pm 0.0005)\pi$
Gu	$X\pi$	–	–		–
Gv	$(0.9999$ $\pm 0.0003)\pi$	$(0.5004$ $\pm 0.0005)\pi$	$(0.9994$ $\pm 0.0005)\pi$	–	

Table 3: **Eigen-decomposition of estimated gates**. Each estimated gate is described in terms of: (1) the eigenvalues of the superoperator; (2) the gate's fixed point (as a vector in $\mathcal{B}(\mathcal{H})$, in the Pauli basis); (3) the axis around which it rotates, as a vector in $\mathcal{B}(\mathcal{H})$; (4) the angle of the rotation that it applies; (5) the decay rate along the axis of rotation ("diagonal decay"); (6) the decay rate perpendicular to the axis of rotation ("off-diagonal decay"); and (7) the angle between each gate's rotation axis and the rotation axes of the other gates. "X" indicates that the decomposition failed or couldn't be interpreted.

3.2 Raw Estimates

Operator	Matrix	Hilbert-Schmidt vector (Pauli basis)	95% C.I. ½-width
ρ_0	$\begin{pmatrix} 0.9994 & 0.0007e^{i0.546} \\ 0.0007e^{-i0.546} & 0.0006 \end{pmatrix}$	0.7071 0.0009 -0.0005 0.7063	0 0.0013 0.0016 0.0004
E_0	$\begin{pmatrix} 0.0005 & 0.0004e^{i0.184} \\ 0.0004e^{-i0.184} & 0.9993 \end{pmatrix}$	0.707 0.0005 -0.0001 -0.7063	0.0003 0.0011 0.0013 0.0004

Table 4: **The GST estimate of the SPAM operations**. Compare to Table **??**.

	E_0	E_C
ρ_0	0.0011 ± 0.0005	0.9989 ± 0.0005

Table 5: **GST estimate of SPAM probabilities**. Computed by taking the dot products of vectors in Table 4.

Gate	Superoperator (Pauli basis)	95% C.I. ½-width
Gx	$\begin{pmatrix} 1 & 0 & 0 & 0 \\ -0.0002 & 0.9501 & -0.0005 & -0.0001 \\ -5\times 10^{-5} & -0.0005 & -0.0005 & -0.9496 \\ 0.0003 & 0.0008 & 0.9497 & 0.0005 \end{pmatrix}$	$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0.0008 & 0.0017 & 0.002 & 0.0015 \\ 0.0006 & 0.0018 & 0.0022 & 0.0009 \\ 0.0004 & 0.0015 & 0.0009 & 0.0018 \end{pmatrix}$
Gy	$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0.0004 & 0.0022 & -0.0012 & 0.9496 \\ -0.0005 & 0.0006 & 0.9501 & 0.0003 \\ -0.0001 & -0.9496 & 0.0015 & 0.0011 \end{pmatrix}$	$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0.0005 & 0.0019 & 0.0018 & 0.001 \\ 0.0007 & 0.0019 & 0.0019 & 0.0017 \\ 0.0004 & 0.001 & 0.0015 & 0.0014 \end{pmatrix}$
Gu	$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0.0001 & 0.9498 & -0.0007 & -0.0008 \\ 0.0002 & 0.0003 & -0.95 & -0.0007 \\ -9\times 10^{-6} & 0.0004 & -0.0003 & -0.9509 \end{pmatrix}$	$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0.0003 & 0.0008 & 0.0013 & 0.0012 \\ 0.0004 & 0.0014 & 0.0008 & 0.0008 \\ 0.0004 & 0.001 & 0.0008 & 0.0006 \end{pmatrix}$
Gv	$\begin{pmatrix} 1 & 0 & 0 & 0 \\ -0.0002 & -0.9496 & -0.0012 & -0.0003 \\ 5\times 10^{-5} & -0.0005 & 0.9502 & -0.001 \\ 0.0001 & 0.0009 & -0.0009 & -0.9501 \end{pmatrix}$	$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0.0003 & 0.0008 & 0.0012 & 0.0008 \\ 0.0002 & 0.0013 & 0.0008 & 0.0011 \\ 0.0005 & 0.0008 & 0.0011 & 0.0006 \end{pmatrix}$

Table 6: **The GST estimate of the logic gate operations**. Compare to Table **??**.