

Comments on HW 4

- Problem 0 – Sample problem
- Problem 1 – T1 mapping – Inversion recovery sequence (01.fid)
- Problem 2- T2 mapping - Spin echo sequence (02.fid)

- Get familiar with data format from Varian scanner
- Reconstruct and analyze images at various inversion times or TE times
- Generate T1 and T2 maps

- 1d) Fitting IR signal to compute T1
- 2d) Fitting spin-echo signal to compute T2

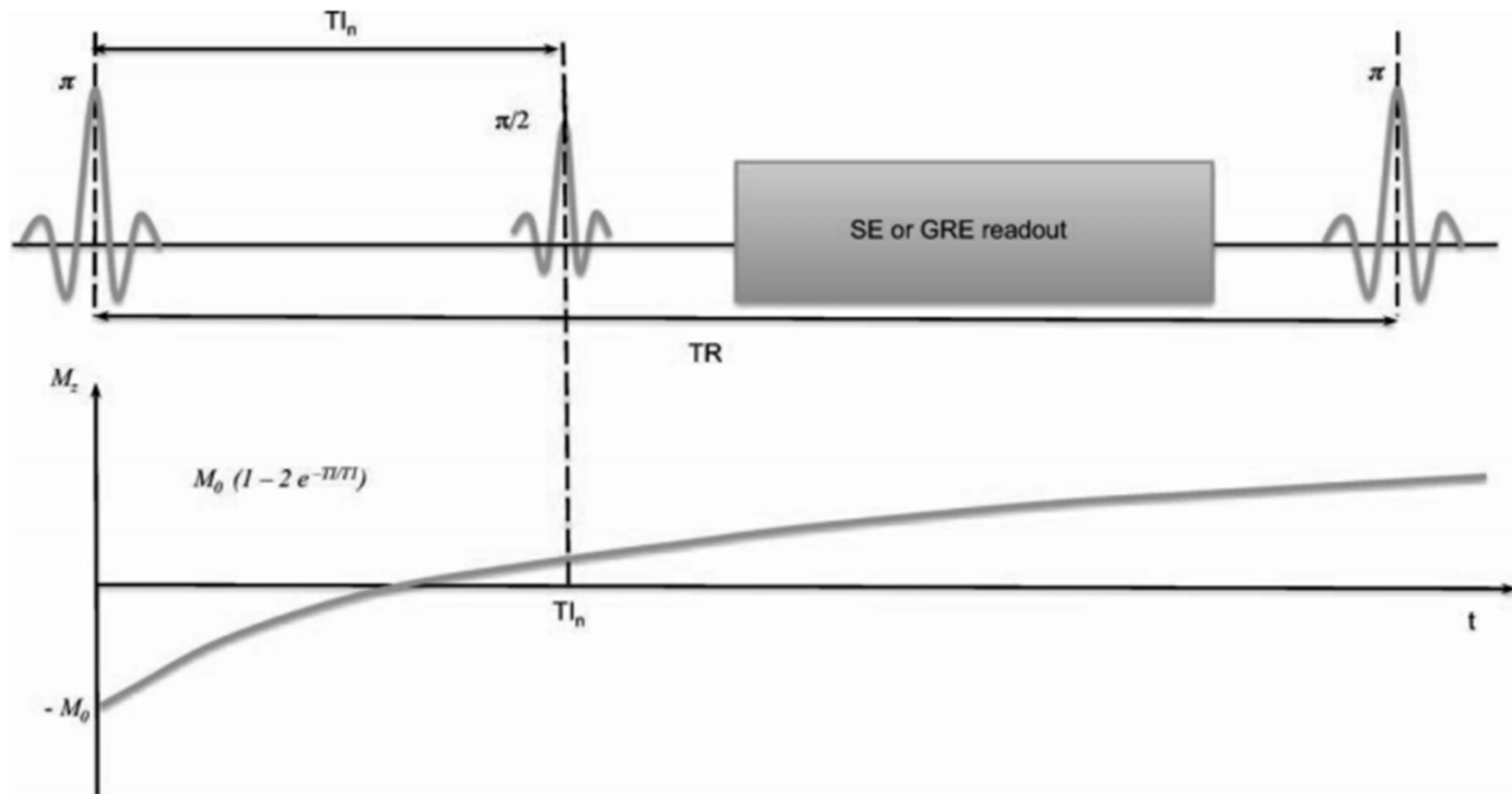
- 2d) is easier: polynomial fitting
- 1d) is more challenging: (magnitude of data has been taken)
 - non-linear fitting, e.g. lsqnonlin
 - requires an initial guess

Building a QMRI Method

- 1) Choose a Model
- 2) Choose a Parameterization
- 3) Choose an Optimization Method
- 4) Acquire and fit data to a model
- 5) Improving A Model: Calibration & Correction
- 6) Validating a Technique:
 - 1) Accuracy vs. precision
 - 2) Monte Carlo Methods

Choose A Model

■ Inversion Recovery Model



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IR Parameterization

$$g(\vec{x}, \vec{\theta}) = g(x_i, \vec{\theta})$$

$$x_i = TI_i$$

$$\vec{\theta} = [M_0 \ T_1]$$

$$g = M_0 \left(1 - 2e^{-TI/T_1} \right)$$

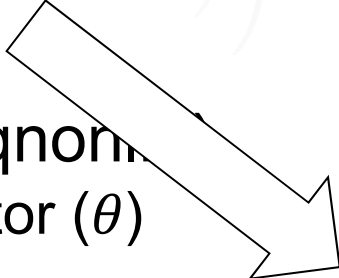
$$g = M_0 \left(1 - 2e^{-TI \cdot R_1} \right)$$

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Optimization Method

$$\hat{\theta} = \arg \min_{\theta} \left(\sum_{i=1}^N (S_i - g(x_i, \theta))^2 \right)$$



χ^2

- Levenburg-Marquardt (MATLAB: lsqnonlin)
 - Minimize difference in parameter vector (θ)
 - No bound / constraints
- Trust-Region Reflective (MATLAB: lsqnonlin)
 - Constrained optimization
- Nelder-Mead Simplex (MATLAB: fminsearch)
 - Minimize cost function (χ^2)
 - Derivative-free optimization
- Global Optimization (MATLAB: ga)
 - Reduce sensitivity to initial guess
 - Avoid local minima for difficult problems (e.g. $\dim(\theta) \gg 1$)

Optimization Method

```

284 %% V. IR Model Function
285 function [g] = ir_model(theta)
286     % Pull out parameters
287     pd_mod    = theta(1);
288     r1_mod    = theta(2);
289
290     % MR Signal Mz (z-magnetization)
291     mz = pd_mod.*(1-2.*exp(-ti.*r1_mod));
292
293     % Output vector
294     F = abs(mz);      % Use sign-sensitive signal
295
296 end

```

```

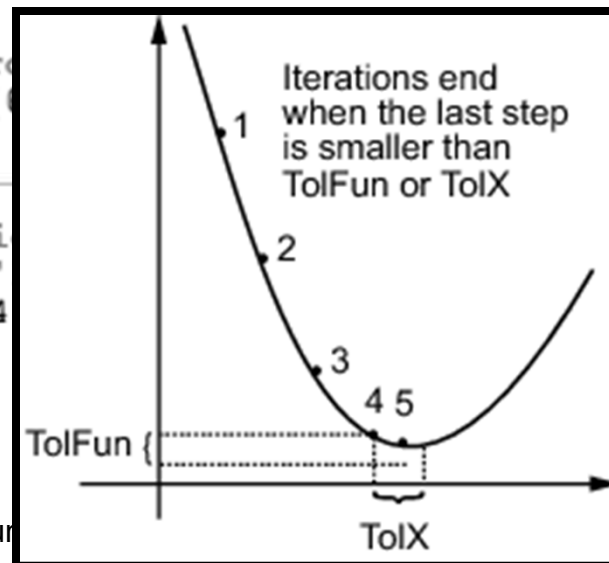
234 - theta_init = [0 0 0];
235
236 % Minimize /w Levenburg-Marquardt
237 - [theta chi_square] = lsqnonlin(
238

```

```

41 %% OO. Optimization settings
42 % Levenburg-Marquardt /w Numerical
43 - optim = optimset('Algorithm', 'Levenburg-Marquardt',
44                   'Tolfun', 1e-4, 'TolX', 1e-4);

```



```

, optim);

```

```

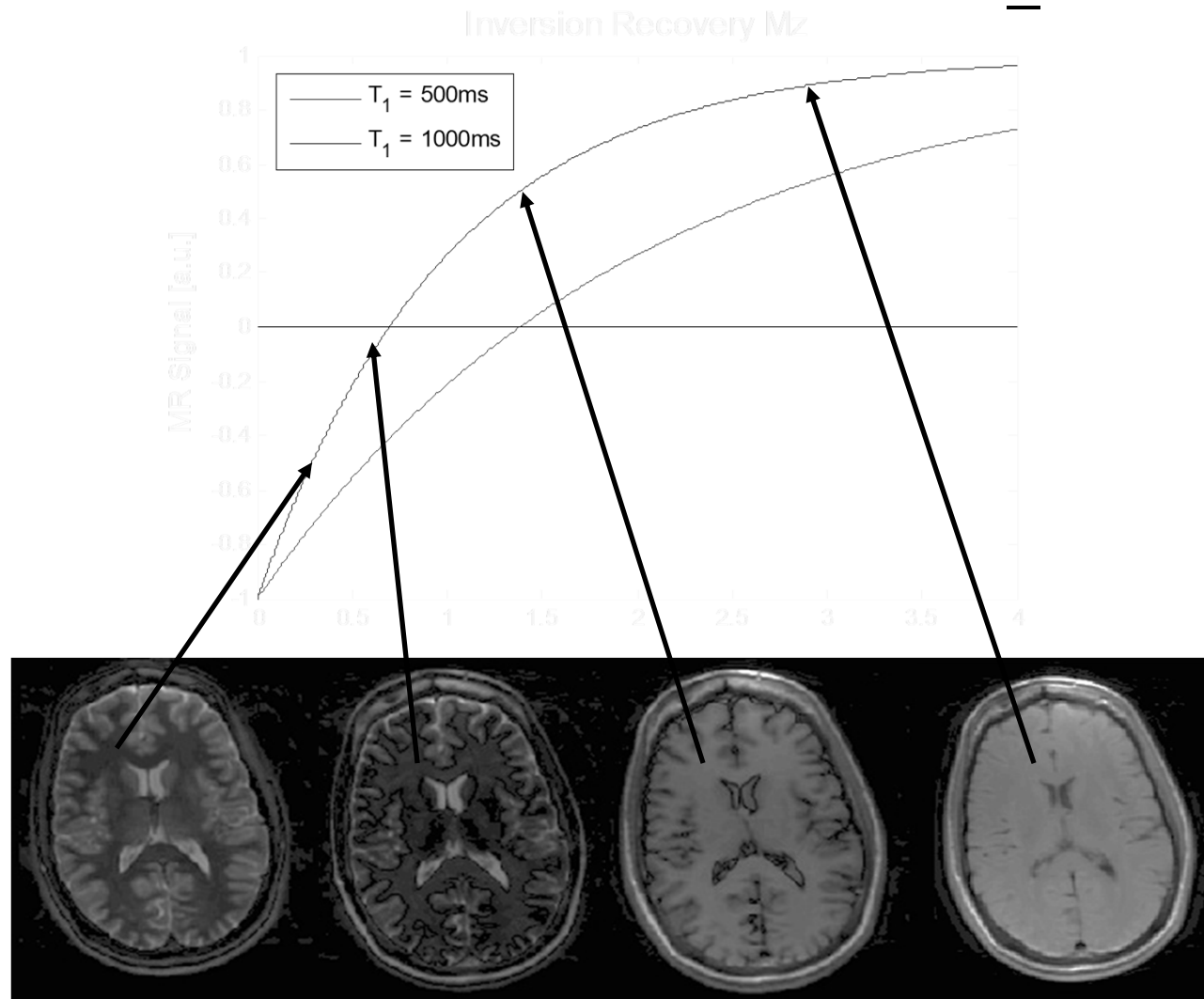
e is 1e-4
an', 'off', ...

```


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Inversion Recovery T_1



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