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

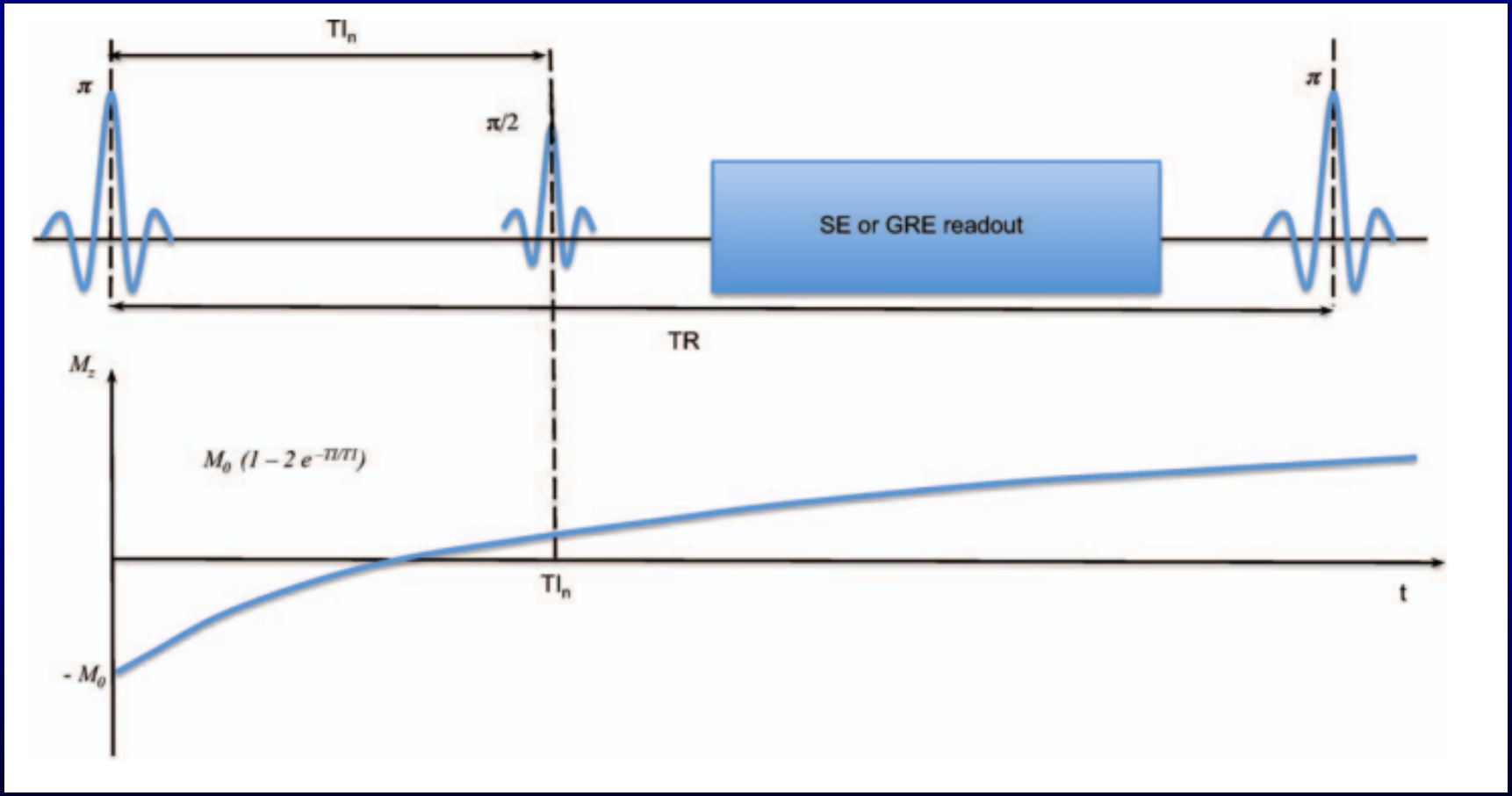
- 2d) is easier: polynomial fitting
- 1d) is more challenging: (magnitude of data has been taken)
  - non-linear fitting, e.g. lsqnonlin
  - requires an initial guess

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

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

$$x_i = TI_i$$

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

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

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

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Optimization Method

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

χ^2

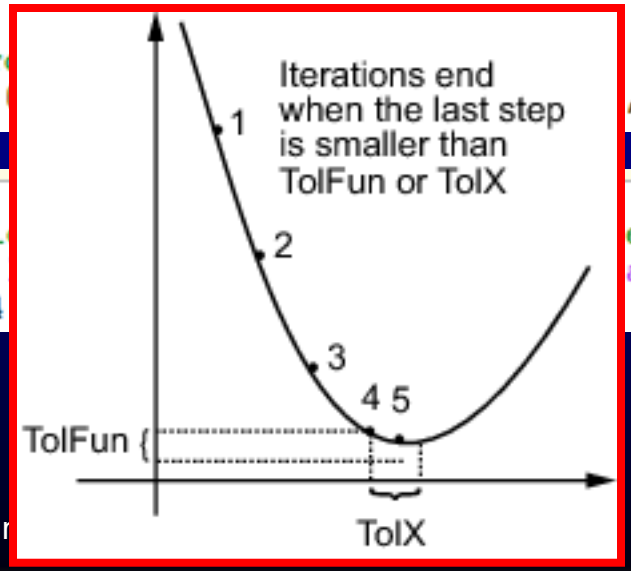
- Levenburg-Marquardt (MATLAB: lsqnonl
  - Minimize difference in parameter vector (θ)
  - No bound / constraints
- Trust-Region Reflective (MATLAB: lsqnonlin)
  - Constrained optimization
- Nelder-Mead Simplex (MATLAB: fminsearch)
  - Minimize cost function (χ^2)
  - Derivative-free optimization
- Global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

Optimization Method

```
%% V. IR Model Function
  function [g] = ir_model(theta)
    % Pull out parameters
    pd_mod    = theta(1);
    r1_mod    = theta(2);

    % MR Signal Mz (z-magnetization)
    mz = pd_mod.*(1-2.*exp(-ti.*r1_mod));

    % Output vector
    F = abs(mz);      % Use sign-sensitive signal

  end
```

```
  theta_init = [0 0 0];

  % Minimize /w Levenburg-Marquar
  [theta chi_square] = lsqnonlin(                    , optim);
```

```
%% OO. Optomization settings
  % Levenburg-Marquardt /w Numeri                    e is 1e-4
  optim = optimset('Algorithm', '                    an', 'off', ...
                   'Tolfun', 1e-4
```



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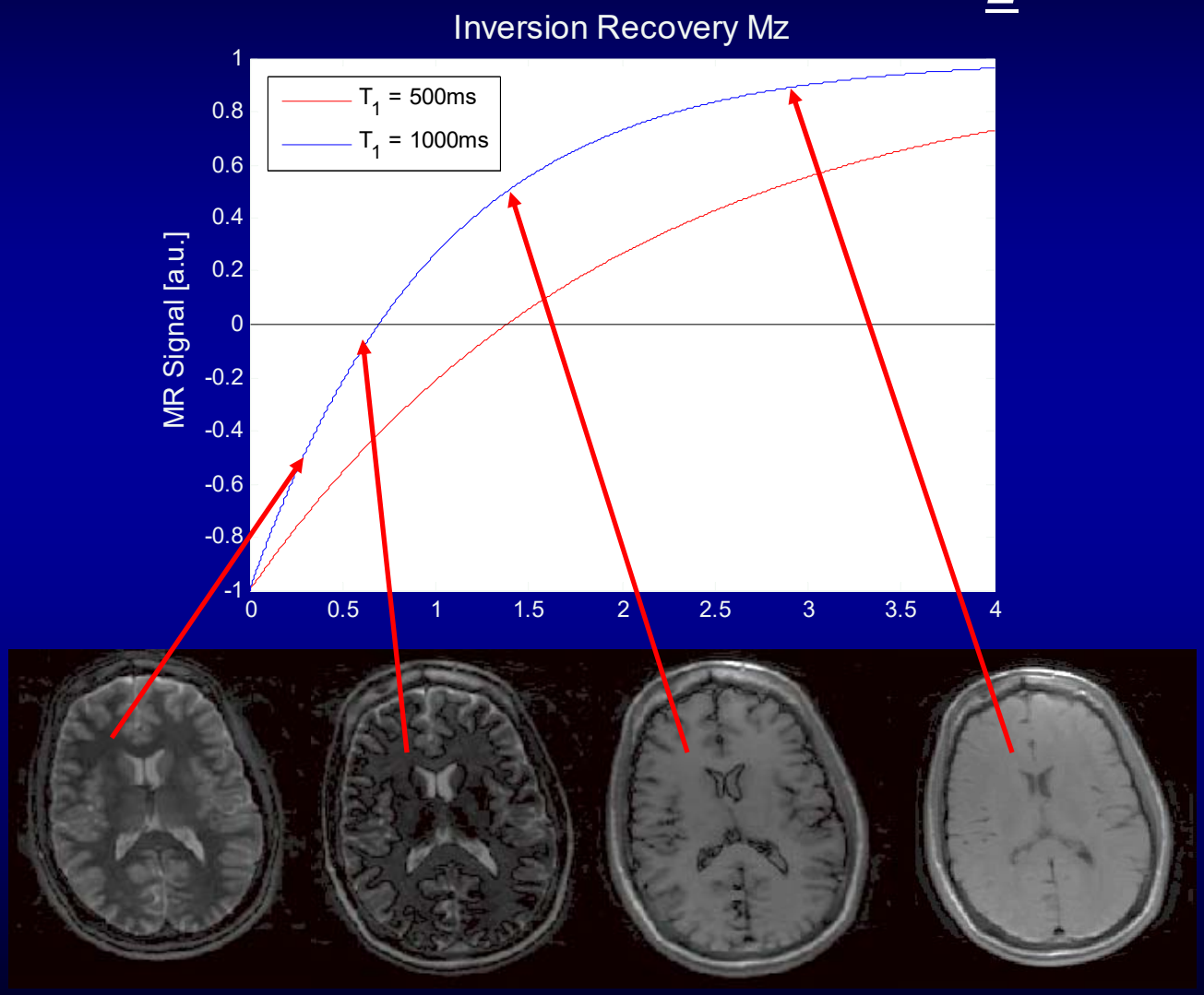
Inversion Recovery T_1



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