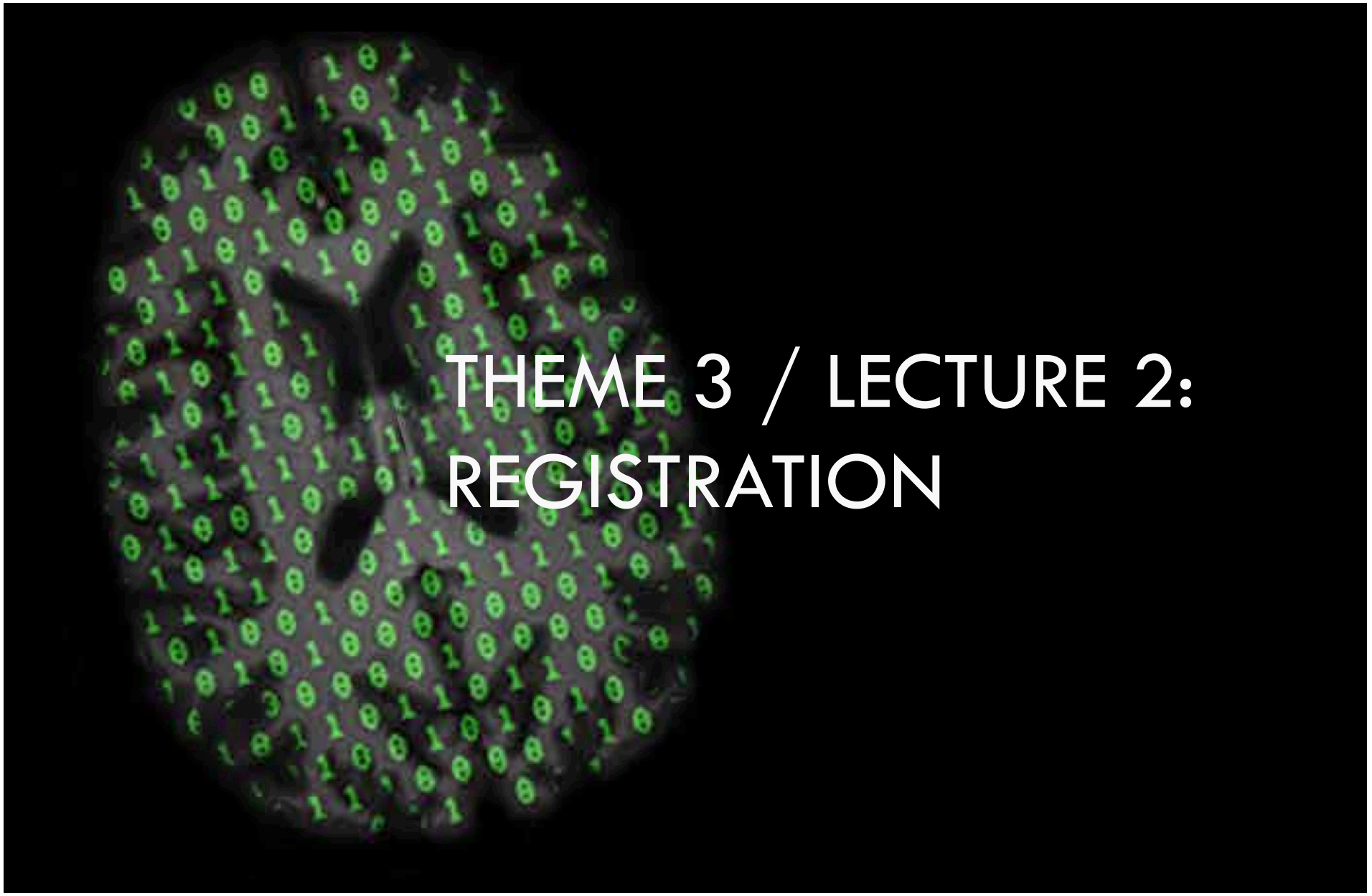
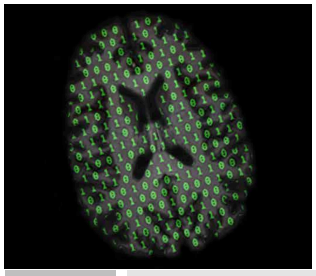
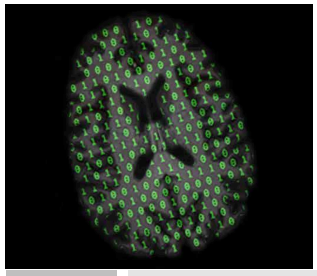


THEME 3 / LECTURE 2: REGISTRATION

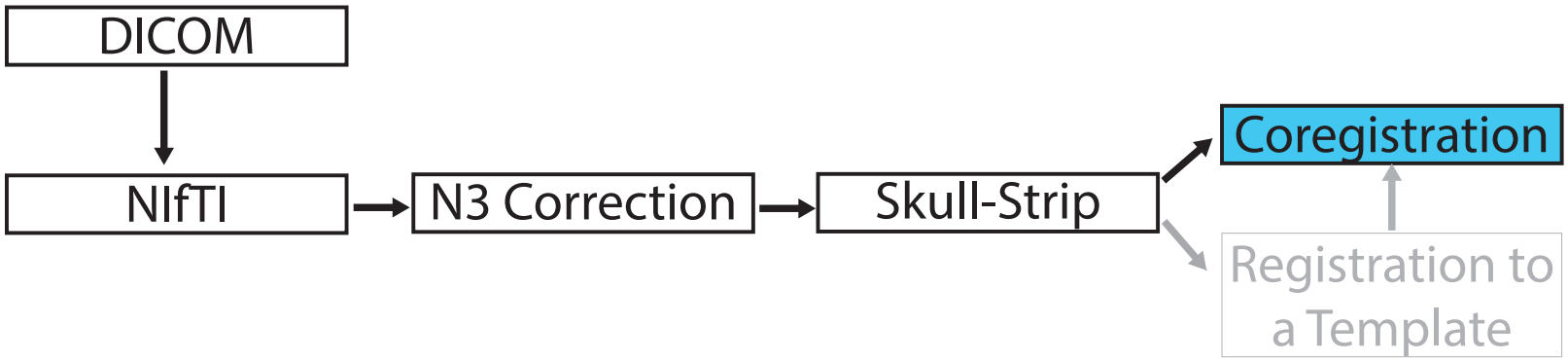


Registration

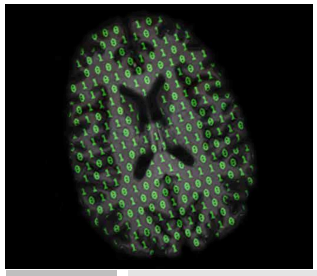
Registration is a spatial transformation of one or multiple images with the goal of making locations (voxels, ROIs) have the same or similar interpretation



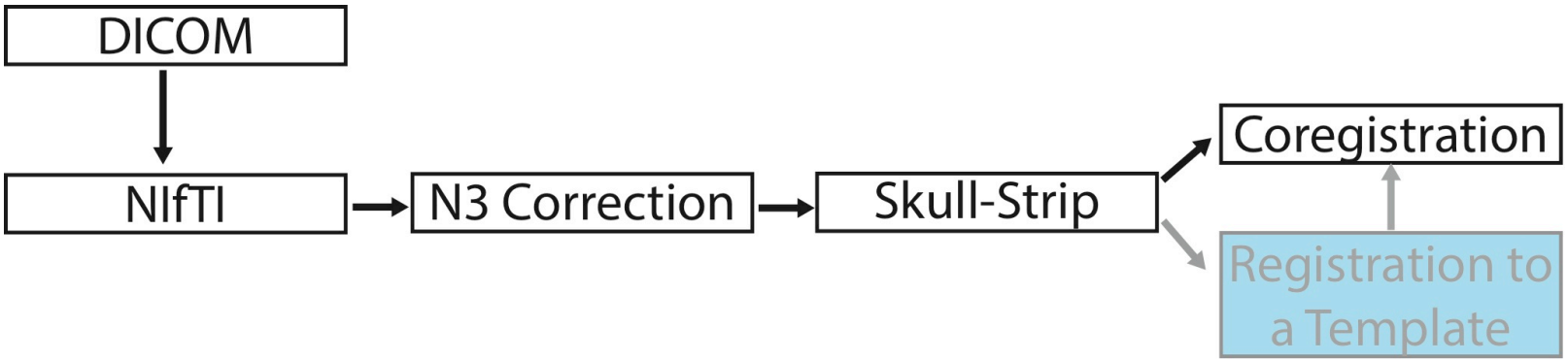
Co-Registration



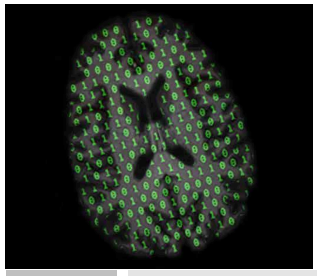
Coregister volumes from different modalities to one another (for example, register the FLAIR to the T1-w volume or register a baseline to a follow-up study)



Registration to a Template

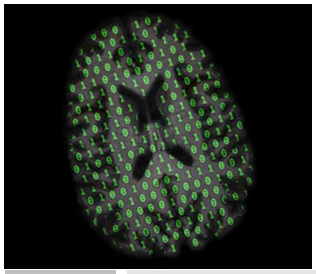


You can also register to a group template (such as the MNI T1-w template)



Types of registration

- Complexity
  - rigid (6df)
  - affine (12df)
  - nonlinear (>12df)
- Co-registration (within the same person)
  - Cross-sectional between-modalities
  - Longitudinal within-modality
  - Longitudinal between-modalities
- Registration to a template
  - A template image is necessary (e.g. MNI template stored in …/data/MNI152_T1_1mm.nii.gz)
  - There are many different templates
- One subject to another



Linear Registration: Rigid

- Rigid registration has 6 degrees of freedom and consists of a translation and a rotation.

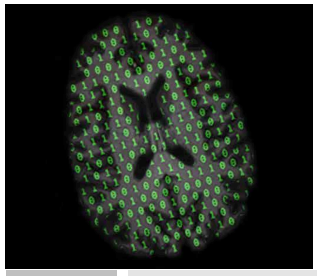
$$T_{\text{rigid}}(v) = Rv + t$$

- Rotation Matrix

$$R = \begin{bmatrix} \cos\beta\cos\gamma & \cos\alpha\sin\gamma + \sin\alpha\sin\beta\cos\gamma & \sin\alpha\sin\gamma - \cos\alpha\sin\beta\cos\gamma \\ -\cos\beta\sin\gamma & \cos\alpha\cos\gamma - \sin\alpha\sin\beta\sin\gamma & \sin\alpha\cos\gamma + \cos\alpha\sin\beta\sin\gamma \\ \sin\beta & -\sin\alpha\cos\beta & \cos\alpha\cos\beta \end{bmatrix}$$

- Translation vector

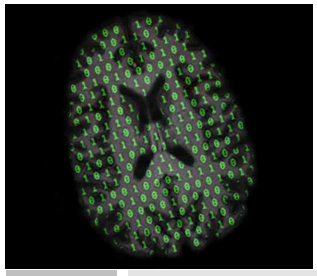
$$t = (t_x, t_y, t_z)$$



Linear Registration: Affine

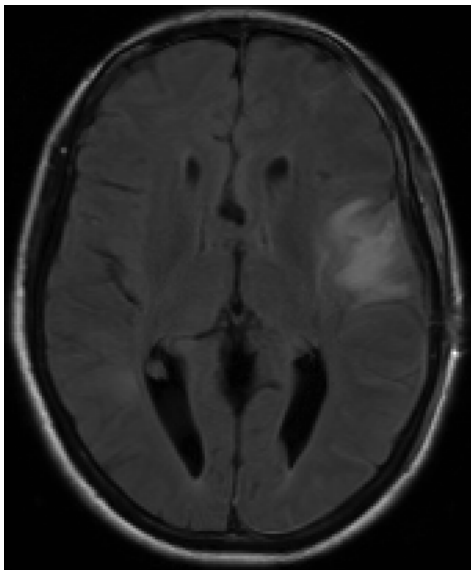
- Affine registration has 12 degrees of freedom
- Same form as the rigid, but the matrix A is not constrained to be a rotation matrix
- A has 9 entries (3×3 matrix) and the translation vector has 3 entries: total "12 degrees of freedom"

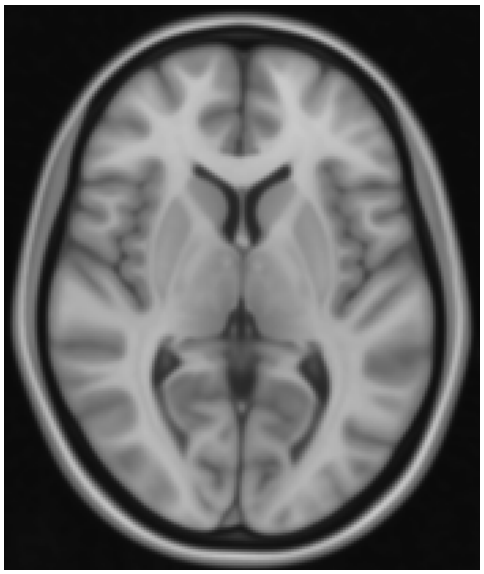
$$T_{\text{affine}}(v) = Av + t$$

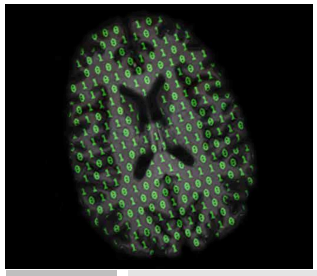


Nonlinear registration

- Co-registration, registration to a template, or from one subject to another

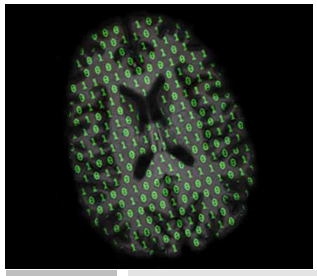






Co-Registration

- Works better and requires fewer degrees of freedom
- Easier to register the same brain
- Analysis examples that do not require a reference template
  - Identify location-specific longitudinal changes
  - Segmentation
  - Analysis of intensities



Registration to a Template

- Assumes that brains can reasonably be morphed to a template space
- Gain anatomical information from the template
- Analysis examples that require a reference template
  - Presenting population level results (e.g. location of lesions)
  - Describing findings at the anatomic level (e.g. the ICH covered more than 30% of thalamus in more than 50% of the patients)
  - Segmentation using multi-atlas label fusion