Supporting Undo and Redo in Scientific Data Analysis

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Scientific data goes through a series of complex transformations.
Undo and Redo in Scientific Data Analysis
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- Undo and redo happen often
  - Undo and redo should not cause restarting from scratch.
  - Intermediate computations need to be taken advantage of.
Complete process provenance (Data Derivation Graph)

- Automatically records detailed process execution history
  - data creations and modifications
  - step execution sequences
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  - step execution sequences
- Extracts process state at any given point
- **Undo**: The provenance overrides the current state with the retrieved state, and drives the process.
The Scenario

- The scientist decides to apply another model.

Our system will
- present the user with a visualization of the DDG.
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Our system will

- present the user with a visualization of the DDG
- retrieve the appropriate execution state the scientist picks
- output the execution state vector and override the current state of the process.
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- New model applied, evaluation suggests the quality control procedure needs to be reverted.

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- present the user with a visualization of the DDG
- retrieve the appropriate execution state the scientist picks
- output the execution state vector and override the current state of the process.
A detailed model of the process (using Little-JIL)
- guides the scientist in undoing and redoing previously executed work in the new context
- allows for tracking & examining the history as the scientist executes it
- manages dataflow and control flow in undo and redo

**Undo**: Identify a previously executed step and invoke Revert

**Redo**: Restore artifact values to previously executed step’s values
A detailed model of the process (using Little-JIL) guides the scientist in undoing and redoing previously executed work in the new context, allows for tracking & examining the history as the scientist executes it, manages dataflow and control flow in undo and redo.

- **Undo**: Identify a previously executed step and invoke `Revert`
- **Redo**: Restore artifact values to previously executed step’s values

The scientist needs to design the process beforehand.
Complete Scientific Data Processing Process Definition

- **Update Process**
  - **Select Update**
  - **Update Calibration**
  - **Update QC**
  - **Update Model**
  - **Update Data**
  - **Process Data**
  - **Apply Calibration**
  - **Apply QC**
  - **Apply Model**

**Input and Output**:
- **in**: data, calibration, qc, model
- **out**: calibrated data, qc data, model data

**Exceptions**:
- **Undo Update Model Exception**
- **Undo Update QC Exception**

**Symbols**:
- **C1**: Calibration 1
- **C2**: Calibration 2
- **Q1**: Quality Control 1
- **Q2**: Quality Control 2
- **M1**: Model 1
- **M2**: Model 2
Complete Scientific Data Processing Process Definition

Entry

Retrieve Data

Set Initial Parameters

Update Data

Update Calibration

Update QC

Update Model

Process Data

Apply Calibration

Apply QC

Apply Model

Select Update

Entry

in: data, calibration, qc, model
out: calibrated data, qc data, model data

in: data
out: data

in: calibration, qc, model
out: calibrated data, qc data, model data

in: data, calibration
out: calibrated data

in: calibrated data, qc
out: qc data

in: qc data, model
out: model data

in: data, calibration, qc, model
out: calibrated data, qc data, model data

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Entry

Undo Update Model Exception

Undo Update QC Exception

 Undo Update Model

Undo Update QC
Revert step retrieves the execution state vector at a selected point.
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Update Model step is redone, followed by another Evaluation.
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Update Model step is redone, followed by another Evaluation.

Exception handlers can be recursive to assist repetitive undo/redo.
Related Work

- **Provenance Visualization**
  - Provenance Map Orbiter [Seltzer et al. TaPP '11] captures large provenance graphs and provides navigation mechanism.
  - Navigation model for scientific provenance [Anand et al. WORKS '09].
  - *DDG takes advantage of Little-JIL's hierarchical structure*

- **Undo Mechanism**
  - [Leeman TPLS ’86] proposed a formal approach to undo operations.
  - Selective undo model [Berlage TCHI '94] provides the user with the ability to undo an arbitrary operation in history.
  - *Our approach takes into account both control flow and data flow*

- **Undo in WFMSs**
  - Kepler tolerates faults by providing check-pointing and forward recovery [Mouallem et al. SSDBM ’10].
  - Self-healing Kepler (periodically constructing checkpoints) [Hary et al. HPDC ’10].
  - *Our approach is complementary and allows undoing work and trying a different strategy when the results are unsatisfactory*
Contributions:

- Undo tasks while remembering old artifacts and consequences
- Modify a data-processing step without losing the history
- Automatically redo set-aside tasks that are consistent with the modification

Our approach is implemented as a command-line tool.

Future Work:

- User interface for browsing and querying the DDG
- Detect conflicts in redo operations