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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- 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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Using the DDG to Undo

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Our system will
- present the user with a visualization of the DDG.
- retrieve the appropriate execution state the scientist picks.
Using the DDG to Undo

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Using the DDG to Undo

The Scenario
- The scientist decides to apply another model.

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.
Using the DDG to Undo

The Scenario

- The scientist decides to apply another model.
- 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
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**The scientist needs to design the process beforehand**
Complete Scientific Data Processing Process Definition

- Entry
- Retrieve Data
- Set Initial Parameters
- Update Data
- Process Data
- Apply Calibration
- Apply QC
- Apply Model
- Select Update
- Evaluation
- Update Process
- Undo Update QC Exception
- Undo Update Model Exception

In: data, calibration, qc, model
Out: calibrateddata, qcdata, modeldata

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Out: calibrateddata

In: calibrateddata, qc
Out: qcdata

In: qcdata, model
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Out: calibrateddata

In: calibrateddata, qc
Out: qcdata

In: qcdata
Out: qcdata

In: modeldata
Out: modeldata

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In: calibrateddata, qc
Out: qcdata

In: qcdata
Out: qcdata

In: modeldata
Out: modeldata

C1, C2, Q1, Q2, M1, M2

Undo Update Model Exception
Undo Update QC Exception
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