RVL Study
Selected Business Use Case Narratives

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0.1	Robert Schwanke	Initial draft	Dec 16, 2010
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1. Introduction

The textual use case narratives provided in this document are derived from a hierarchical use case category model developed for the imaging workspace as part of the AVT development program. They are a deliverable under an AVT contract.

The use case titles and numbers (e.g. “conduct RVL study (UC-0059)” match use case categories in that model. Each narrative given here should be regarded as an informal guide to the primary “normal” path through the corresponding use case, and most of the principal alternate paths. Being a textual narrative, it cannot capture all the variations in control flow that are possible.

The diagrams included in this report have also been added to the model. They are activity diagrams with data flow paths between activities. In most cases each of the activities can be repeated as many times as desired, in any order, subject only to the constraint that the results of the whole use case will not be consistent unless the last occurrence of each of the activities happens in the order implied by the connecting arrows.

Rather than distinguish optional activities from mandatory ones in the diagram, all activities are assumed to be optional wherever there is a reasonable interpretation of what it means to skip the activity.

1.1. Scope of this document

This document is intended to provide narratives for the following use cases, which were selected by the caBIG IMAG workspace leadership:

- UC-0180 prepare RVL task forms
- UC-0191 annotate RVL series, in two variants:
    - UC-0170 markup RECIST diameter
    - UC-0171 markup RVL volume
- UC-0033 automatic batch markup
- UC-0025 analyze statistical variability
- UC-0262 Validate segmentation algorithm

1.2. What This Document Is Not

caBIG, in general, and the IMAG workspace in particular, have been developing a collection of Enterprise Use Cases to support the specification and validation of the second-generation caBIG architecture. This document is not part of that effort, although it adopts a very similar documentation style to facilitate future harmonization of use-cases.

This document is also not a replacement for, or a successor to, the RVL Study hierarchical use-case model. That model contains several hundred use cases, at many different levels of granularity. There was no intent to provide narratives covering all of them, as this was regarded as not maintainable and not necessary for further development of software to support them.

Finally, these use cases are business use cases, not system use cases. That means that they deliberately try to avoid specifying which activities are performed by humans, which by computers, and which by a combination (this avoidance is not always successful). It also means that they are described without reference to a particular system architecture or a particular implementation. Therefore, neither the use case model nor these narratives are intended to provide sufficient detail to begin implementation. Before that can happen, the business model must be mapped to a proposed external architecture and to a system use case model that specifies what the system will do.

2. UC-0180 prepare RVL task forms

A task form is an electronic document that specifies the image reading task that is to be performed, by a person and/or an algorithm, as part of an RVL study.

2.1. Context: UC-0077 curate RVL collection

Curating an RVL collection includes the following activities.

- Define the case inclusion criteria
- Identify candidate patients for the study
- Select the cases to include in the study
- Define the image annotation instructions
- **UC-0180 prepare RVL task forms**
- Test the annotation instructions
- Assign the reading tasks to readers and sessions
- Manage the annotations

2.2. Preconditions

- The cases to include in the study have been selected
- The annotation instructions have been defined

2.3. Flow of Events

The following is the logical flow of events. The actual flow is opportunistic, meaning that the reader actually performs the steps of the task in whatever order is convenient, repeating them as many times as desired to achieve satisfactory results.

A. Select a case to create a task for
B. Select a DICOM series from those of the task
C. Select a tumor appearing in the series
D. Select a task form, one of:
    1. Select an existing task form
    2. Copy an existing task form to make a new one
    3. Create a task form from scratch
E. Do one of the following:
    1. Delete the task form
    2. Try the task form in a “sandbox” environment to make sure it has the right information in it.
    3. Edit the task form, by doing the following:
        a. Load the series into a viewer
        b. Navigate to the tumor

c. Do zero or more of the following:
    - Give the tumor a name
    - Mark the tumor location
    - Specify the “given” characteristics of the tumor
    - Specify the “to be captured” characteristics of the tumor
    - Set the initial presentation state of the viewer that the reader will see at the beginning of the task.
    - Attach the annotation instructions to the task form
    - Specify the slice thickness to be used for the task (an integer multiple of the slice thickness in the DICOM series.)

d. Either save the task form or cancel the changes made in the previous step.

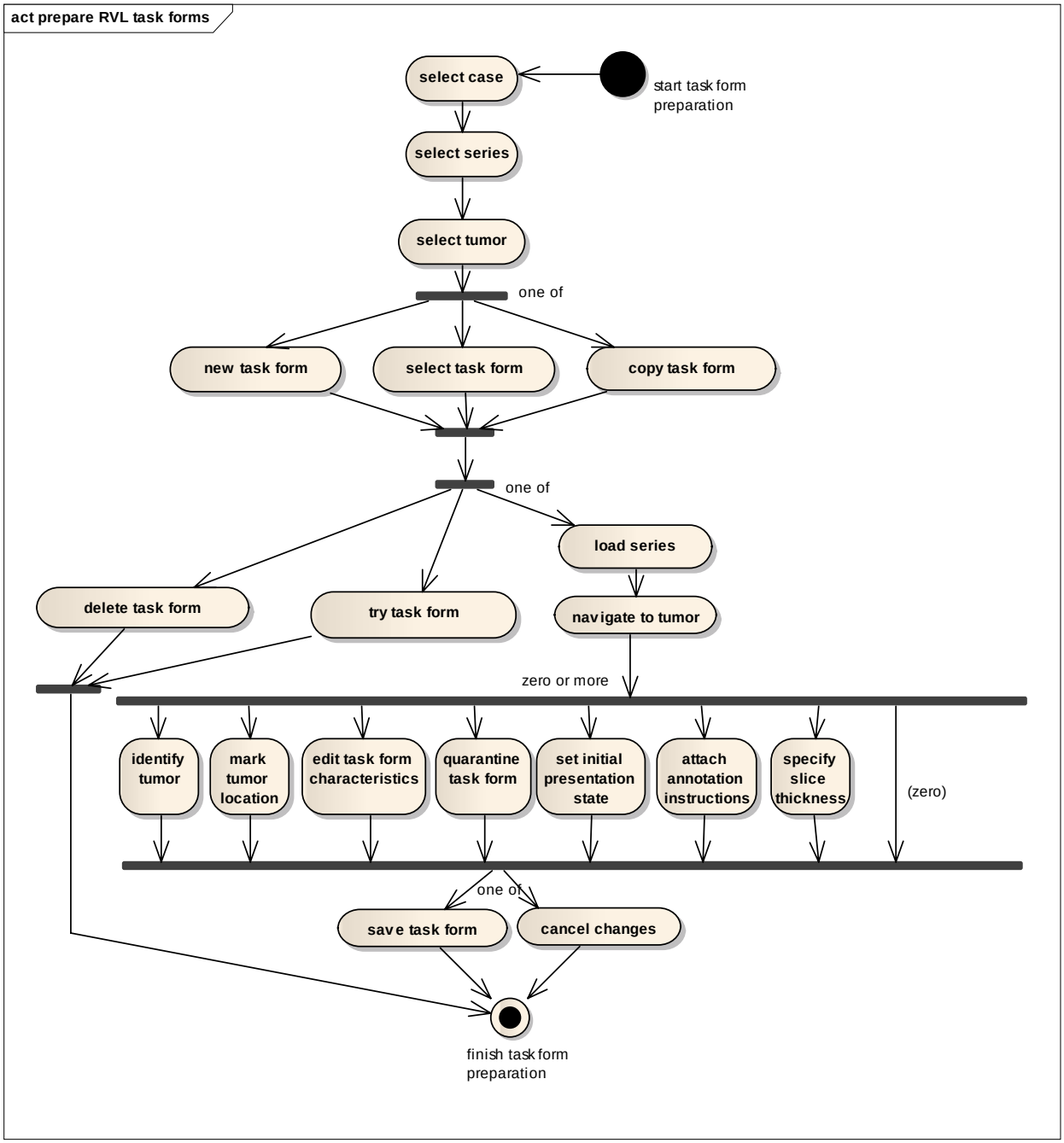
F. Repeat the steps above as many times as needed.

2.4. Postconditions

- A task form has been created for each reading task that is to be included in the RVL experiment.

2.5. Alternate Flows

None. All of the error and exception cases are handled by either canceling changes (E.3.d) or deleting task forms (E.1).


act prepare RVL task forms
select case
start task form preparation
select series
select tumor
one of
new task form
select task form
copy task form
one of
load series
delete task form
try task form
navigate to tumor
zero or more
identify tumor
mark tumor location
edit task form characteristics
quarantine task form
set initial presentation state
attach annotation instructions
specify slice thickness
(zero)
one of
save task form
cancel changes
finish task form preparation

3. UC-191 read RVL series

Reading a series is the most common task being studied in an RVL study. It entails analyzing an image of a tumor to provide a measurement of the tumor and additional, textual observations and characteristics.

This section describes two variants of this use case: one where the reading task is a RECIST markup, and one where it is a volumetric markup.

3.1. Context: conduct RVL study (UC-0059)

An RVL study is conducted on previously-acquired DICOM series. It consists of four main activities:

- Curate RVL collection (UC-0077)
- **Read RVL series (UC-0191)**
- Compare RVL markups (UC-0054)
- Analyze RVL variability (UC-0024)

3.2. Pre-conditions

- A worklist has been prepared, containing one electronic task form for each reading task to be performed.
- This worklist has been assigned to a specific reader.
- Each electronic task form specifies the information needed to read one tumor with one kind of markup, including
    - Set-up parameters for the image reading tool, such as pan and zoom, window and level, screen layout configuration
    - Restrictions on features of the tool, limiting what the reader is allowed to do with it, such as changing the window and level settings.
    - The location of the tumor
    - The graphic to display to indicate which tumor to read.
    - The name of the tumor
    - The markup task(s) to be performed
    - The textual observations and characteristics that the reader is expected to report.
    - (more)
- The reader's monitor has been calibrated.

3.3. Flow of Events

The following is the logical flow of events. The actual flow is opportunistic, meaning that the reader actually performs the steps of the task in whatever order is convenient, repeating them as many times as desired to achieve satisfactory results.

A. choose task from worklist

B. load an electronic task form and DICOM series into a reading tool, setting the tool up according the information specified in the task form.

C. read instructions given in electronic task form

D. examine DICOM series in MPR viewer

E. visualize DICOM series in 3D viewer

F. markup RECIST diameter (UC-0107) *[Alternative: markup RVL volume (UC-0171)]*

1. In MPR viewer, navigate to axial slice that appears to contain largest diameter of tumor.
2. Using RECIST drawing tool, draw line segment representing longest diameter.
3. Compare drawn line to other axial slices to verify that the best slice was chosen and longest diameter found.
4. Adjust RECIST line segment until satisfied.
5. The tool calculates the length of the line segment.

G. select observations and characteristics from restricted choices as specified in electronic task form.

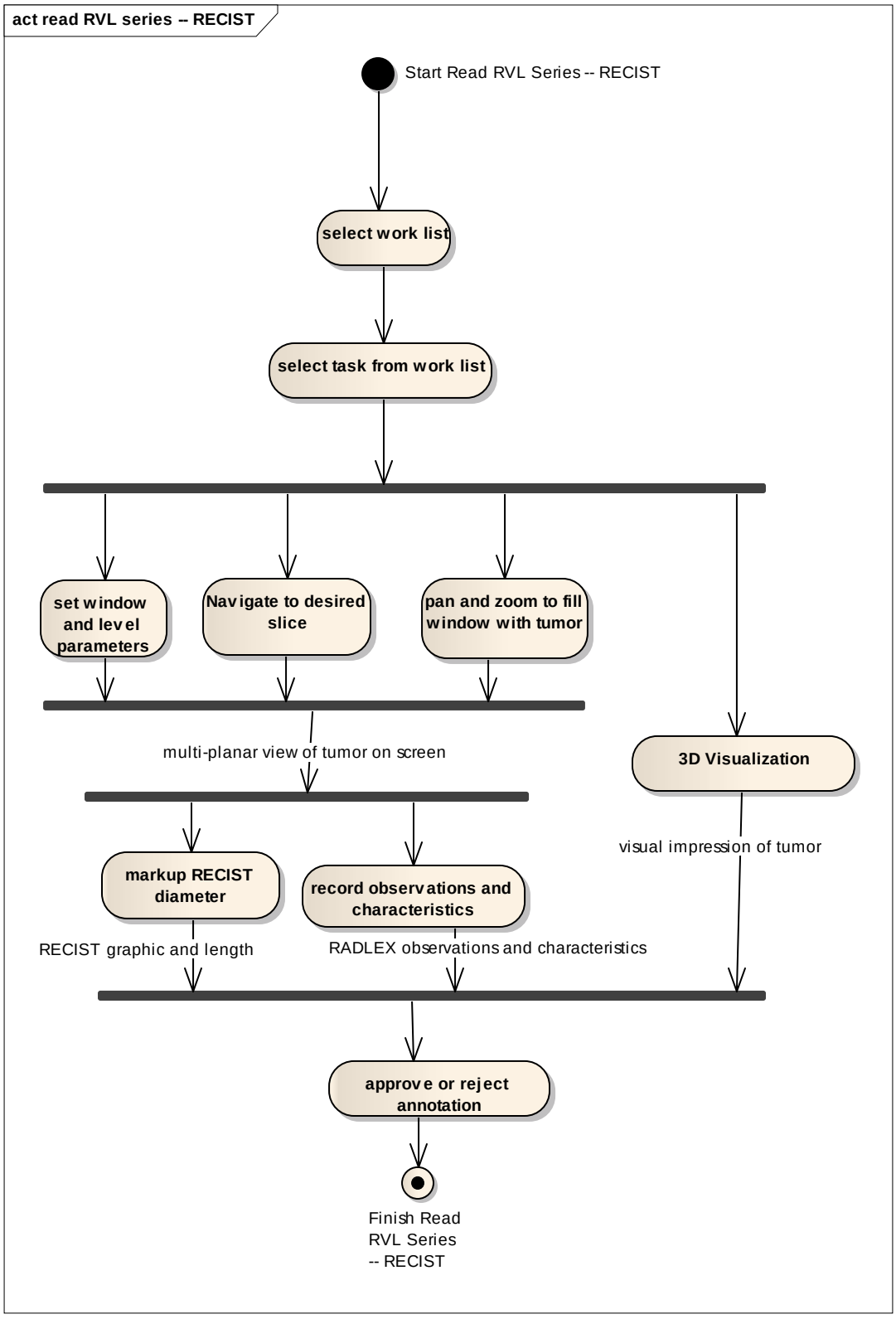
H. add free-text comments if permitted by electronic task form.

I. save work [Alternative: cancel task, discarding any previously saved work on this task]

J. end task

3.4. Post-conditions

- End points of the RECIST diameter of the tumor (in the reader's opinion) are recorded.
- Length of the RECIST diameter has been computed and recorded.
- Additional observations and characteristics of the tumor have been recorded.



3.5. Alternative Flow: MarkUP RVL Volume (UC-0171)

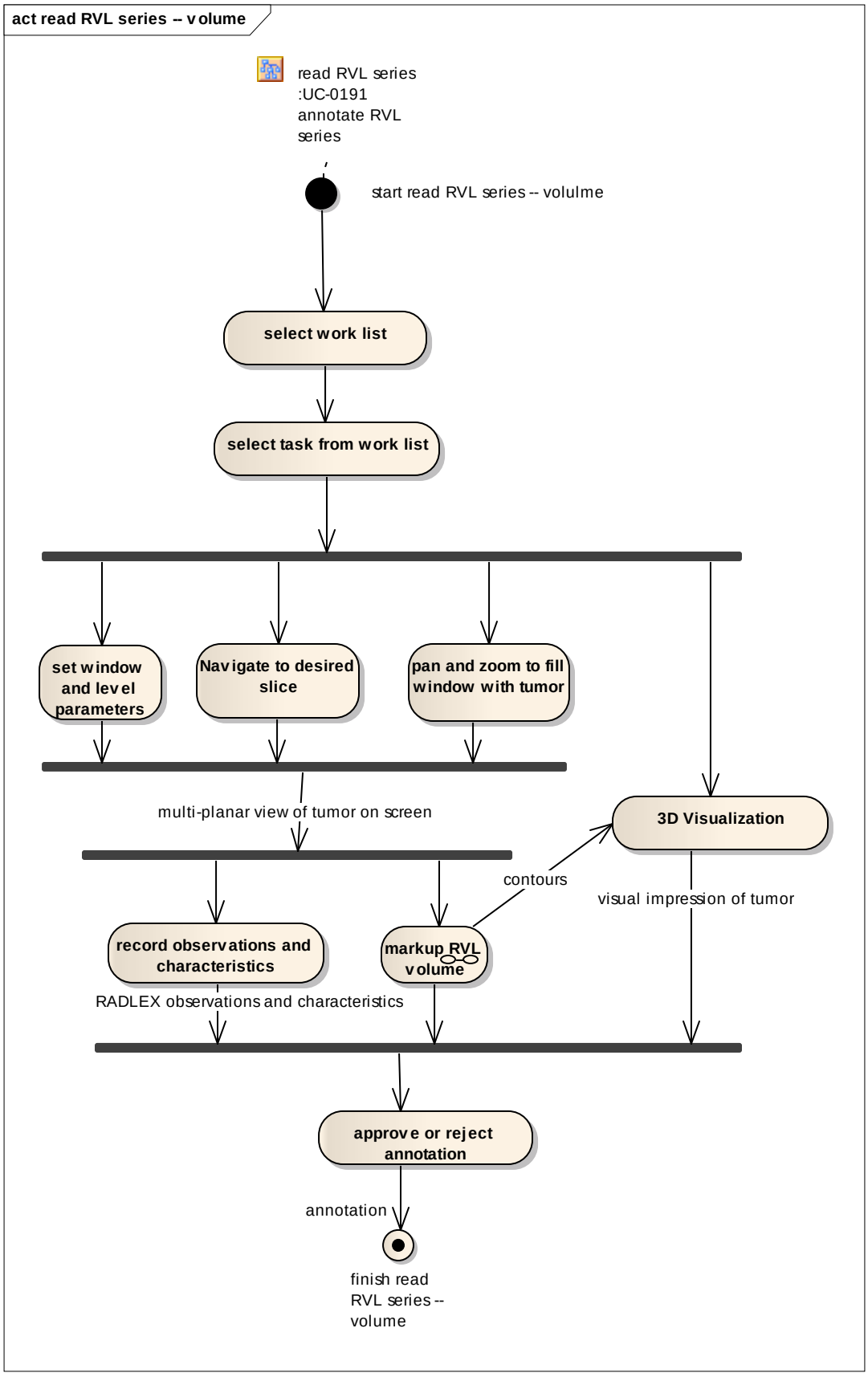
This flow substitutes for the single step above labeled “markup RECIST diameter (UC-0107)”

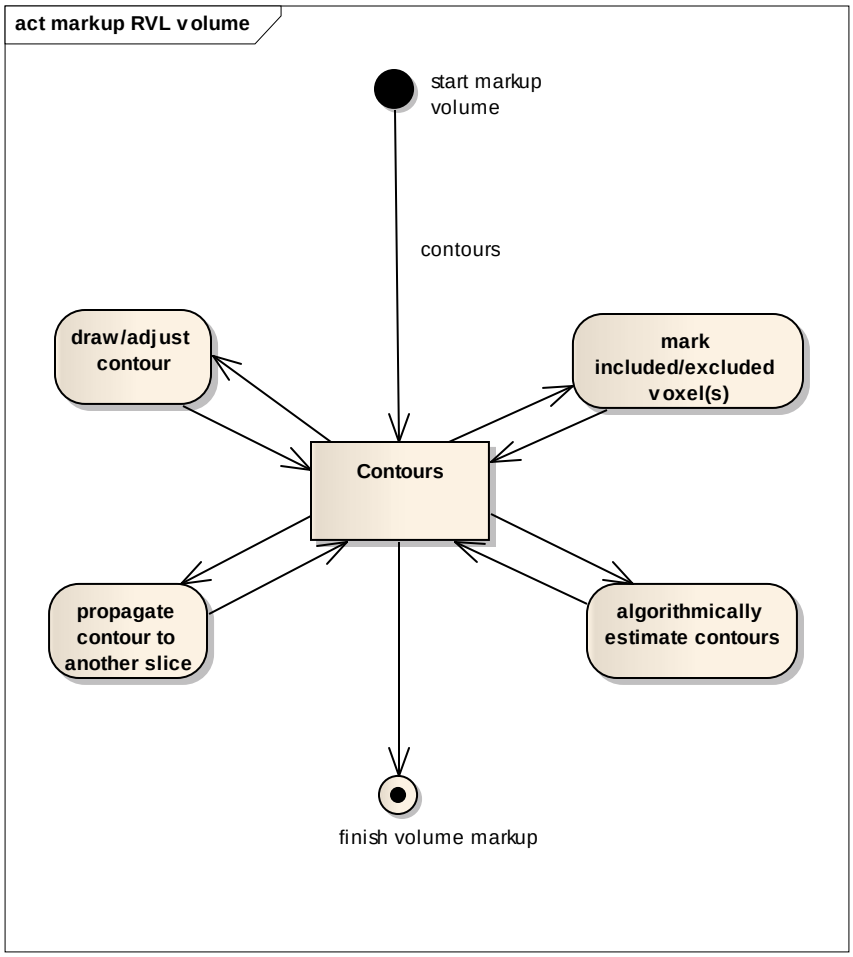
F. markup RVL volume (UC-0171)

1. (Optional) mark a seed point or seed stroke for use by an algorithm
2. (Optional) run an algorithm to estimate and mark the tumor boundary
3. (Optional) interactively mark or adjust the boundary of the tumor
4. Review the marked boundary on each axial slice
5. (Optional) Review the tumor location, especially with respect to nearby structures, in a 3D visualization window.
6. The reading tool calculates the volume and (optionally) RECIST diameter of the marked boundary.

3.6. Post-conditions of the alternative flow

- Boundaries of the tumor (in the reader's opinion) on all of the slices where it appears are recorded.
- Volume of the bounded region has been computed.
- Endpoints and length of the RECIST diameter of the bounded region have been recorded.
- Additional observations and characteristics of the tumor have been recorded.


act read RVL series -- volume
read RVL series
:UC-0191
annotate RVL
series
start read RVL series -- volulme
select work list
select task from work list
set window and level parameters
Navigate to desired slice
pan and zoom to fill window with tumor
multi-planar view of tumor on screen
3D Visualization
contours
visual impression of tumor
record observations and characteristics
markup RVL volume
RADLEX observations and characteristics
approve or reject annotation
annotation
finish read RVL series -- volume


act markup RVL volume
start markup volume
contours
draw/adjust contour
mark included/excluded voxel(s)
Contours
propagate contour to another slice
algorithmically estimate contours
finish volume markup

4. UC-0033 automatic batch markup

Automatic batch markup is a special case of “Read RVL Series”, where the reading is done by an algorithm.

4.1. Context

Same as for Read RVL Series. See section 3.1

4.2. Preconditions

- Desired algorithm has been installed in a batch execution supervisory tool.
- Desired task forms have been prepared.

4.3. Flow of Events

The following is the actual flow of events (unlike the other narratives).

A. Do all of the following in any order:
   1. Select the algorithm and its parameters.
   2. Supply textual reading attributes that should be copied into the results of each reading.
   3. Select the task forms that specify the images and tumors on which the algorithm will be performed.

B. Start the batch execution by passing the above information to the batch execution tool.

C. Monitor the execution by periodically examining the output of the batch execution tool.

D. Do one of the following:
   1. Abort the execution of the tool, selecting which results you want to save in the database.
   2. Allow the batch execution to complete, saving all the results.

4.4. Postconditions

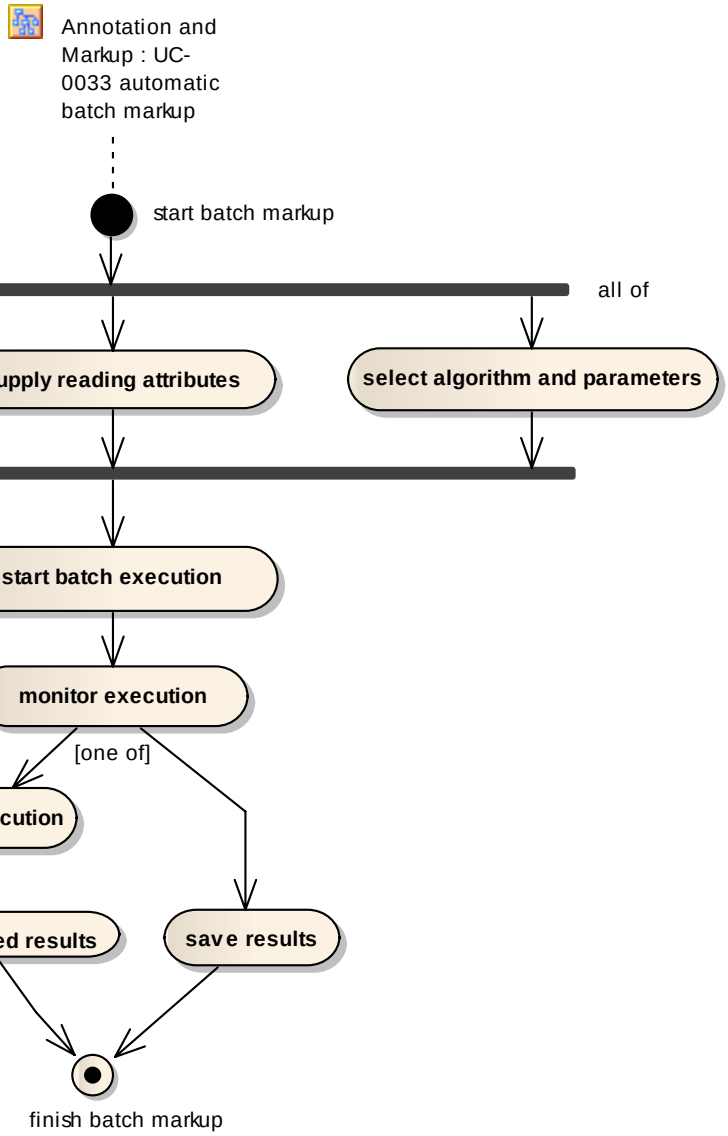
- The batch tool has provided a summary record of the outcome of each automated reading task.
- Either all or a selected subset of the task results have been saved in the experimental database.

4.5. Alternate Flows

- The experimenter can abort the sequence of events at any time without damage.

act automatic batch markup

Name: automatic batch markup
Author: rws
Version: 1.0
Created: 7/11/2010 8:43:49 PM
Updated: 1/10/2011 4:15:44 PM



5. UC-0025 analyze statistical variability

This use-case is a generic formulation of what most statisticians do most of the time. The next chapter describes a specialized form of it.

5.1. Context: UC-0024 analyze RVL variability

This is a high-level category covering the statistical workflows needed for RVL studies. *Each of the following workflows is a special case of "***analyze statistical variability***".*

- UC-0262 Validate segmentation algorithm
- UC-0185 analyze sources of variation
- UC-0023 analyze RVL reader variability
- UC-0074 compare volume and RECIST measures
- UC-0020 analyze indicators of clinical progression
- UC-0073 correlate tumor change with clinical indicators

5.2. Preconditions

- A study design has been written.
- The experimental data and reference data have been collected.

5.3. Flow of Events

The following is the logical flow of events. The actual flow is opportunistic, meaning that the reader actually performs the steps of the task in whatever order is convenient, repeating them as many times as desired to achieve satisfactory results.

A. Study the prior art related to the current experiment and incorporate it into the study design.
B. Select the hypotheses to be tested.
C. Calculate the required sample size
D. Select the data to be analyzed
E. Configure and/or program the statistical analysis methods
F. Calculate the statistics
G. Review the statistical results, to explore the data and/or test the hypotheses.
    - This analysis feeds back into step 2, causing new hypotheses to be selected.
H. Export the data
I. Store and reload the analysis

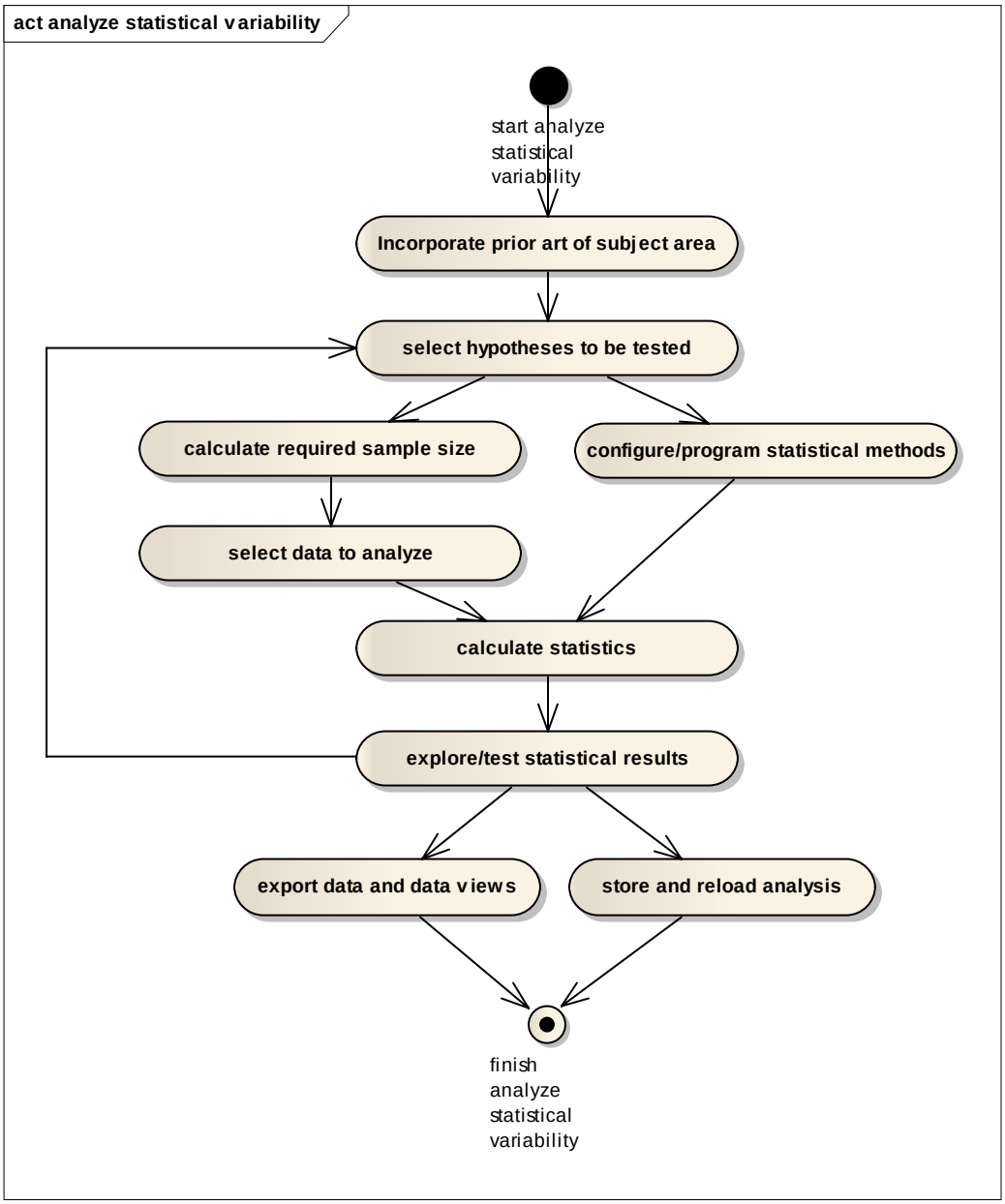
5.4. Postconditions

- Some hypotheses have been tested
- Some new hypotheses have been generated

- The results of the statistical analyses have been exported (for use in publication or further analysis).

5.5. Alternate Flows

- None. The experimenter can stop at any time, without harm, and can change the hypotheses and the statistical methods as needed.



6. UC-0262 Validate segmentation algorithm

This is one of the earliest and most important goals for cancer imaging research.

6.1. Context: UC-0024 analyze RVL variability

This is a high-level category covering the statistical workflows needed for RVL studies:

- **UC-0262 Validate segmentation algorithm**
- UC-0185 analyze sources of variation
- UC-0023 analyze RVL reader variability
- UC-0074 compare volume and RECIST measures
- UC-0020 analyze indicators of clinical progression
- UC-0073 correlate tumor change with clinical indicators

6.2. Preconditions

- A study design for validating a segmentation algorithm has been written.
- The experimental data and reference data have been collected.

6.3. Flow of Events

The following is the logical flow of events. The actual flow is opportunistic, meaning that the reader actually performs the steps of the task in whatever order is convenient, repeating them as many times as desired to achieve satisfactory results.

A. Evaluate measurement accuracy by “analyzing statistical variability” of the segmentation algorithm results compared to gold standard segmentations of the same tumors.

B. Analyze the sources of variation in the segmentation algorithm results by

   1. Selecting the independent variables most likely to explain the variation.
   2. Correlating the volume difference measures used in the statistical analysis, to see which ones should be retained in the final analysis.
   3. “Analyzing statistical variability” of the segementation results with respect to the independent variables, using methods such as multiple regression and ANOVA.
   4. Use the results of the previous step to estimate the confidence intervals on the segmentation algorithm measurements, as they depend on the independent variables.

C. “Analyze the statistical variability” of the segmentation results compared to a reference set of segmentation results produced by other methods (manual and/or algorithmic).

D. Rerun the above analyses, restricting the analysis to “difficult-to-measure” tumors (determined, for example, by noticing which tumors and which DICOM series were most likely to produce measurement outliers.)

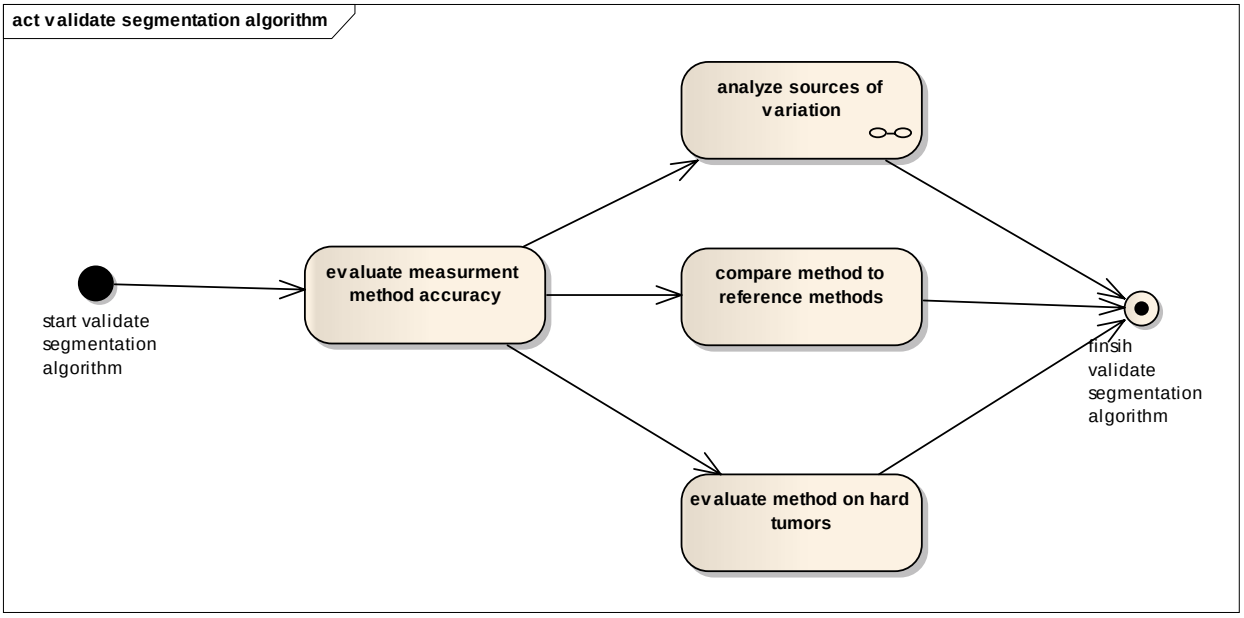
6.4. Postconditions

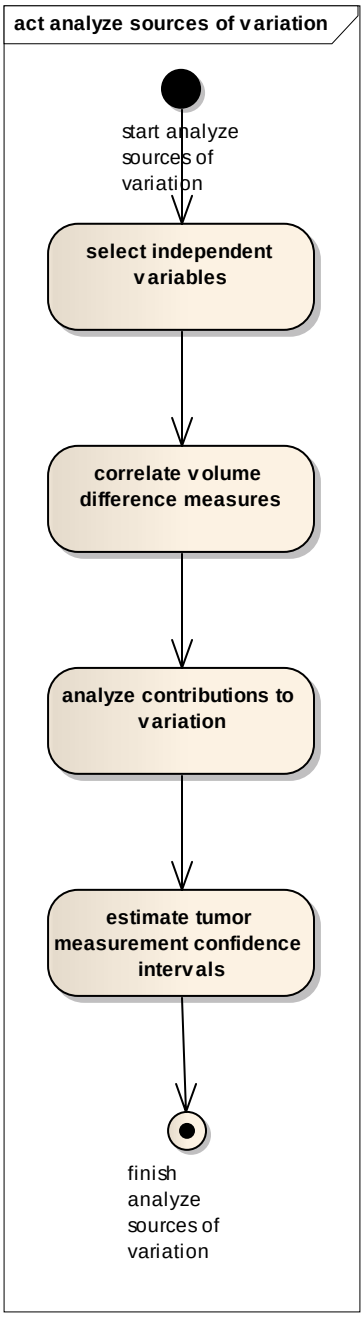
- The accuracy and repeatability of the segmentation algorithm is known.
- The sensitivity of the algorithm to selected independent variables is known.

- Confidence intervals for the segmentation algorithm are known.
- The performance of the algorithm has been compared to other algorithms and to human readers.
- The robustness of the algorithm for measuring “difficult-to-measure” tumors is known.

6.5. Alternate Flows

- None. The experimenter can stop at any time, without harm, and can change the hypotheses and the statistical methods as needed.





End of Report