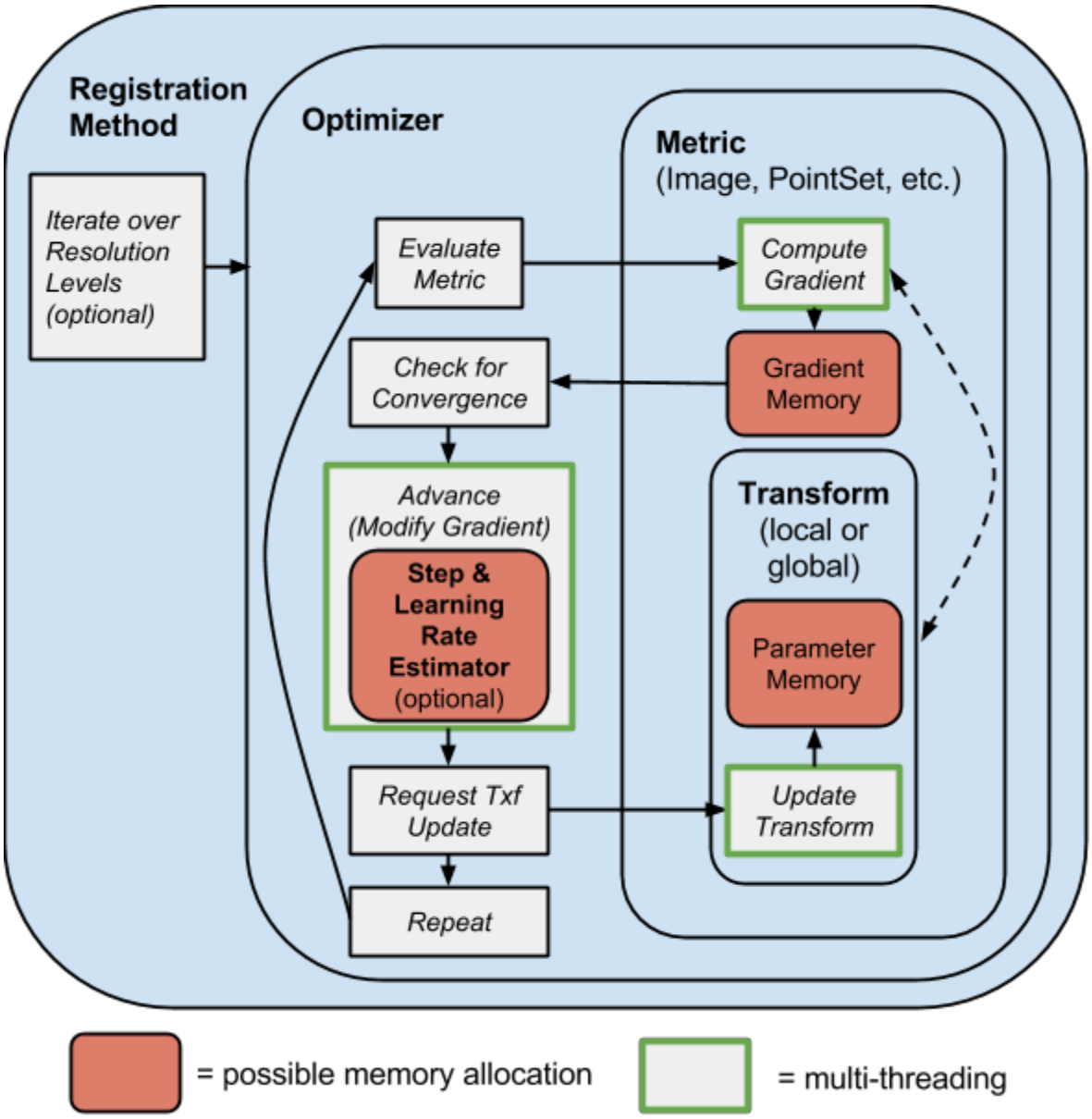
ITKv4 Registration Framework



New Design Features

Single framework for local/deformable/displacement and global transformations [Not sure of desired terminology]

- Greatly simplifies development of metrics to handle both local and global transform types.
- Greatlly simplifies registration methods that combine local and global transforms.

Generalized “object-to-object” metric and optimizer frameworks

- Support for metrics and optimizers that operate on various data types such as point-sets, images, etc.
- Allows shared code and more robust development.
- Allows metrics that combine different data types, e.g. new MultiMetric class.

Improvements in memory efficiency

- Memory optimizations are critical for efficient use of large local transforms.
- Transform parameters are no longer copied within the optimizer, but rather left in-place in transform.
- Metric gradient memory is shared between optimizer and metric, and modifications by the optimizer are done in place when possible.

Improvements in speed

- Metric multi-threading is achieved using a common parallelization helper class for better standardization between metrics.
- Optimizer design allows for easier multi-threading of derived classes.

New transform parameter model

- New class hides details of parameter implementation from transforms and the rest of the pipeline, and implements transform parameter updating within transform themselves.
- Allows transparent parameter handing, provides a common interface and simplifies future expansion of parameter types.
- Allows transforms to handle different complex parameter types.
- Allows transforms to implements different parameter-updating methods, e.g. different smoothing methods for bspline transforms, independent of the rest of the pipeline.
- Allows the new composite transform to contain transforms with different parameter-update methods.

Virtual Domains

- Metrics now integrate a virtual domain rather than always working in the fixed domain.
- Simplifies implementation of unbiased registration.
- Other?

New Capabilities

Multi-variate pixel support

- Added support for variable-length pixel types within metrics.
- Greatly simplifies the use of a wider range of data, e.g. DTI images.

Automated parameter scaling and learning rate estimation

- Used in optimizers.

- Greatly simplifies registration initialization for the user by automatically setting reasonable parameter scales.
- Enables constant-shift/adaptive-step optimization. [terminolgy?]
- Simplifies development and implementation of additional methods.

CompositeTransform

- New class contains multiple separate transforms, concatenating them by composition.
- Allow independent optimization of its component transforms.
- Greatly simplifies the process of multi-transform optimization.
- Directly usable at any point in the pipeline.

TransformParameterAdaptors

- Helper class to facilitate multi-resolution registration.

New Optimizers

- MultiGradientOptimizerv - enables multi-objective optimization.
- MultiStartOptimizer - optimizes over a large number of starting points and returns the best solution.
- QuasiNewtonOptimizer - implements a Quasi-Newton optimizer with BFGS Hessian estimation.

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Performance/accuracy improvements

[From 6/12 ITKv4 Reg Update doc:

Improved performance:

An evaluation of the revised registration pipeline showed considerable improvement in performance in comparison to the best registration available in previous versions of ITK. In a brain mapping study, we found that ITKv4 significantly improves brain overlap in a number of structures when compared to ITKv3. A set of v4 examples, evaluation studies and scripts will be finalized and time-stamped for the WBIR 2012 conference and released via github. The example evaluations will mature and be updated with the v4 methods. We are also implementing an evaluation of ITKv4 longitudinal registration performance for a MICCAI 2012 challenge.]