COSCH^{KR} ontology – the basis for a platform recommending 3D and spectral digitisation strategies

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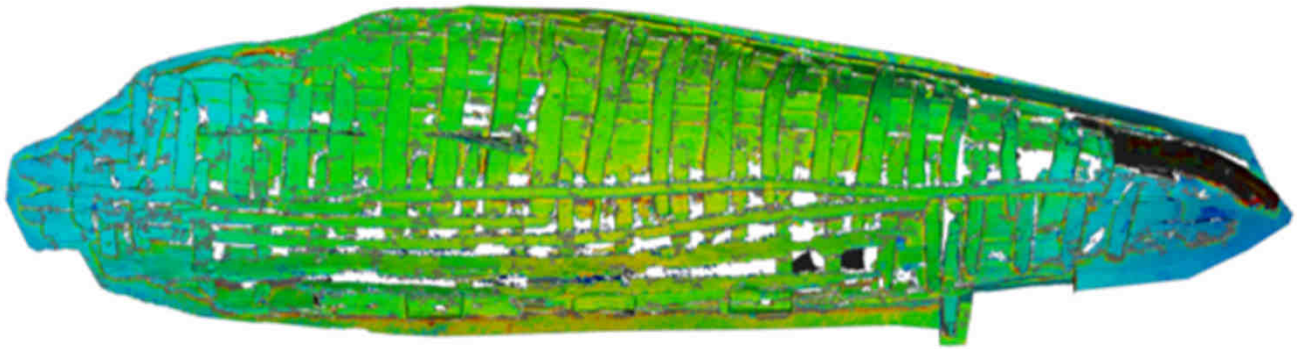
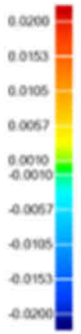
COSCH
COLOR & SPACE IN CULTURAL HERITAGE

Motivation

- Digital documentation of CH objects is an interdisciplinary task of CH-, spatial/spectral recording-, IT-, and visualisation experts.
- Which digitisation strategy is best suitable depends on the
  - CH application (= data usage)
  - CH object parameters (e.g., appearance, size)
  - Digitisation device and method (e.g., measurement principles)
  - Data processing (e.g., registration)
- content & quality of digital representations vary





Roman vessel

(385-400 AD),

8.3 m long

Dependency in between of characteristics: resolution and accuracy

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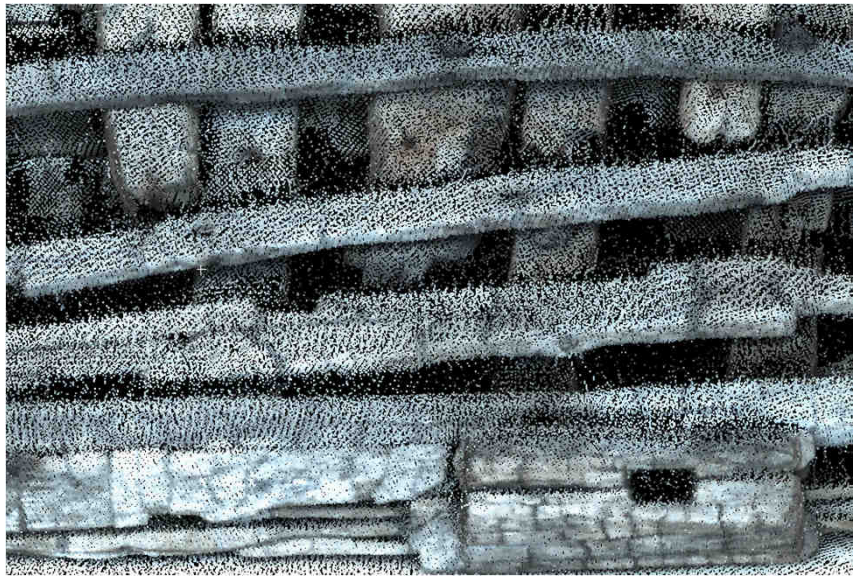
Context: documentation of a Roman ship wreck

Terrestrial Laser Scanning **vs.** **Images (Structure from Motion)**



Resolution: **lower** **higher**

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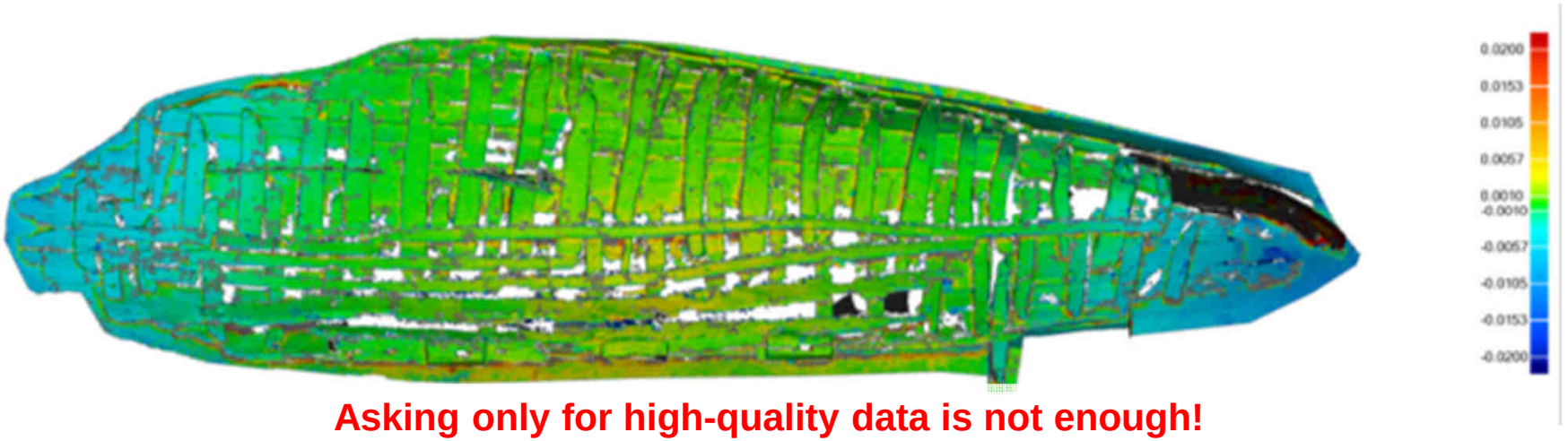
Dependency in between of characteristics: resolution and accuracy

COLOR & SPACE IN CULTURAL HERITAGE

Context: documentation of a Roman ship wreck

	Terrestrial Laser Scanning	vs.	Images (Structure from Motion)
Global accuracy:	**higher**		**lower**



Asking only for high-quality data is not enough!
Which recording strategy is suitable depends on the CH object, CH application, the capabilities of the recording device, and the data processing.

Motivation

- Bridge the gap between the various experts involved in the digitisation of CH objects through a platform under development which will give recommendations for recording strategies based on the information about the CH object and the intended data usage.
- COST Action TD1201: Colour and Space in Cultural Heritage (COSCH) provided the opportunity.
  It is a multidisciplinary European network of humanists, conservators, and engineers.

Idea

COSCH develops a web based system so-called

COSCH$^{\text{Knowledge Representation}}$ Application (COSCH^{KR} App)

- A user of this web based system would need to provide **information about** a **CH object s/he would like to record**, related **external influences**, and the intended **application** of the digital data.
- Based on the user's input the platform will give **recommendations** which recording strategy is best suited to fulfil all input requirements.

Idea

- CH experts will benefit from this web based system as they will receive objective recommendations which s/he could use asking technical experts for specific offers.
- Technical experts will benefit from this web based system as they will receive more specific requests from CH experts.

  Furthermore, they could check their own approaches.

What is COSCH^{KR}?

What is needed to create such a web based system?

- We have to develop an ontology knowledge model (so-called COSCH$^{Knowledge\ Representation}$).
- This ontology structures all necessary knowledge about all decisive factors in the decision making how a physical thing (= CH object) has to be recorded to best fulfil the conditions of the targeted application.
- The web based system will use this ontology knowledge model.

The ontology is expressed in Web Ontology Language (OWL).

Strategy

- What do we need to do to create the COSCH^{KR} ontology?
  - We have to determine the scientific disciplines involved in spatial and spectral recording of CH objects: spectral recording experts, spatial recording experts, CH experts, IT experts.
  - We have to **structure the knowledge (define a theoretical superstructure from experiences and empirical data)**
    - Starting with the domain specific knowledge and then
    - relate the structured knowledge to each other

Strategy

- Background and basis is the fact that a deterministic relation exists between
  - the requirements of a CH application on spatial, spectral, and visual digital information of a CH object which itself has concrete physical characteristics, and
  - the technical possibilities of the spectral and spatial recording devices.
- We are developing a domain ontology.
  - It is a schematic model that will be used to infer recommendations at the schema level.
  - It will express a theoretical concept about the decision making of a technical expert choosing the best suitable spatial or spectral recording strategy.

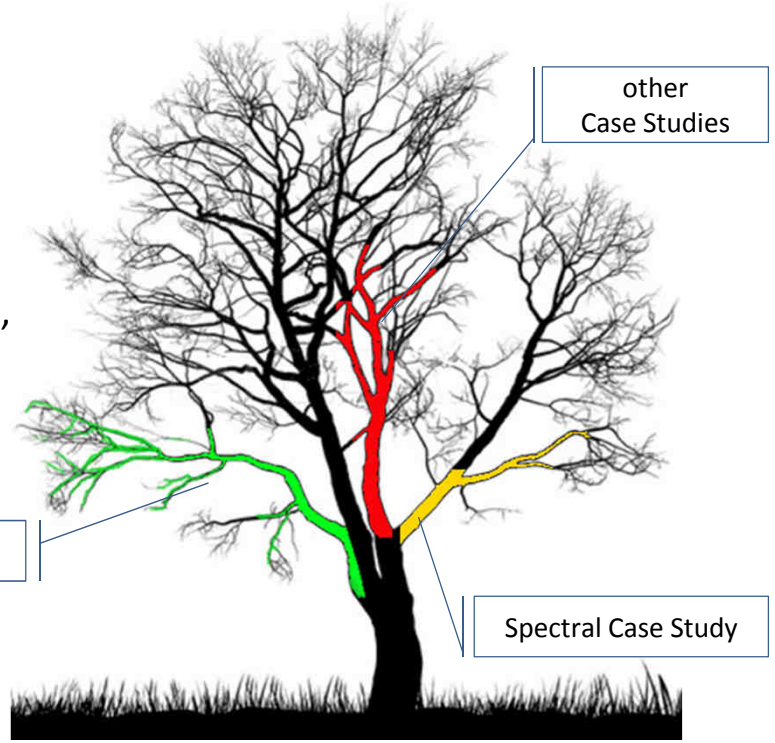
Strategy

- What do we need to do to create the COSCH[KR] ontology?
  - Imagine the ontology being a tree
    - with a trunk
    - and many deliquescing branches.
    - From branch point to branch point the description of a topic is getting more and more detailed.

- We have to create such a tree →each branch at a time

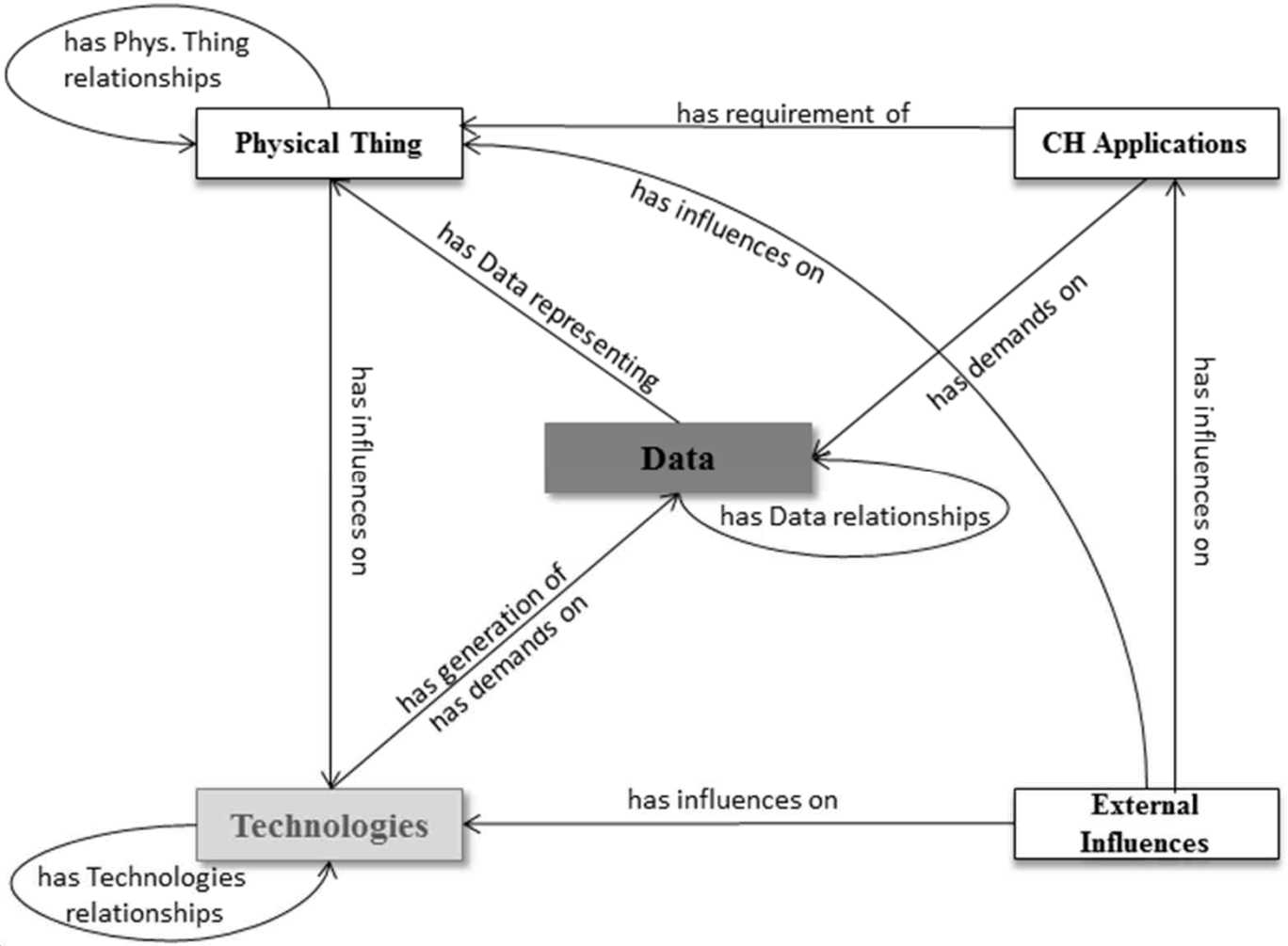
Strategy

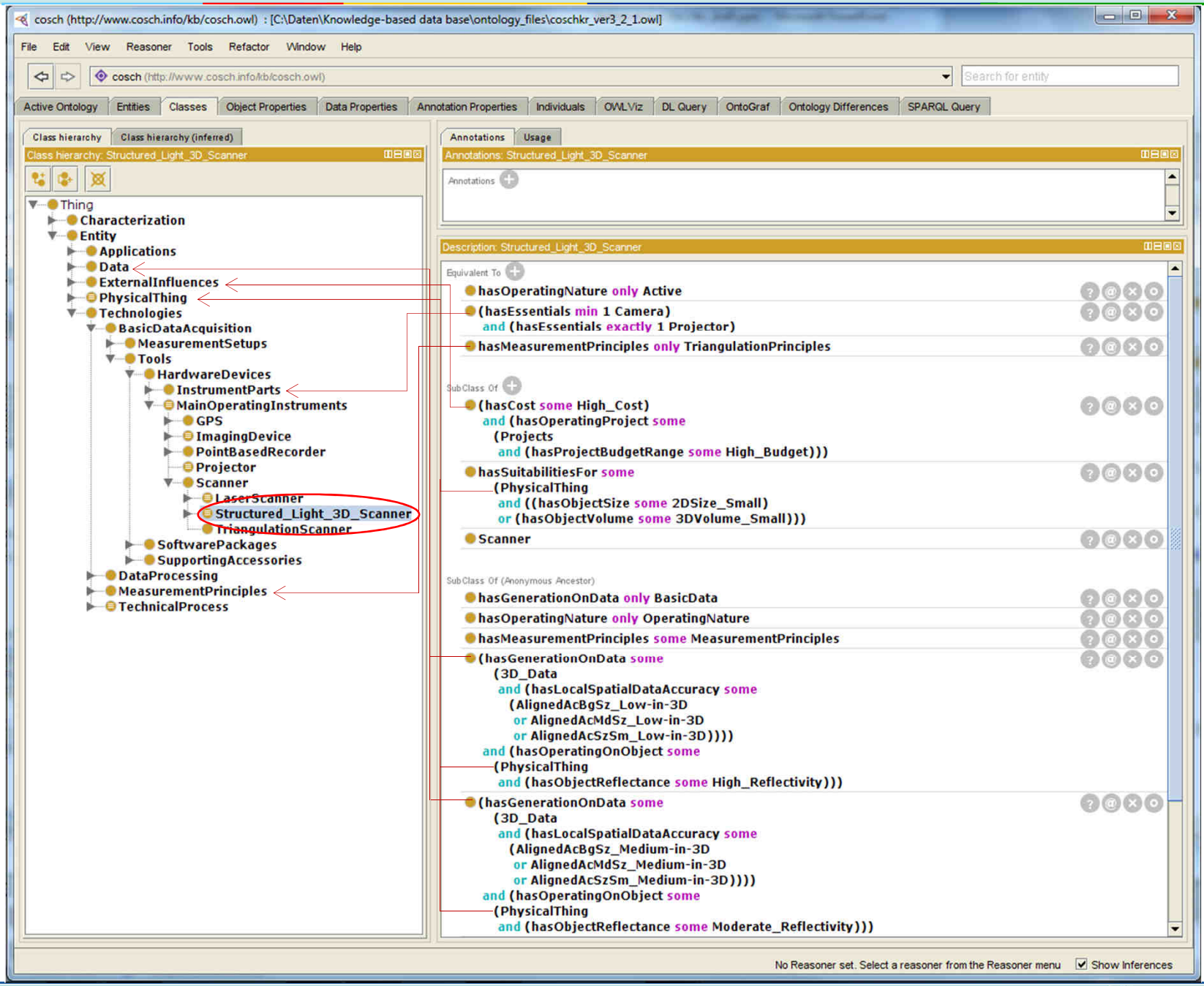
- How to structure the knowledge?
  1) Most important to create a consistent hierarchical structure are discussions:
     1) These discussions focus on specific CH Applications making it more easy for all partners:
        1) Spatial Case Study
        2) Spectral Case Study
  2) It was decided to create five main branches: *Physical Thing*, *CH Applications*, *External Influences*, *Technologies*, *Data*.
  3) E.g. the branch *Technologies* was split into: *Data Processing*, *Tools*, *Measurement Principles*, *Technical Processes*.



Strategy

Most important are the rules and dependencies which link the five top-level classes and sub-classes.

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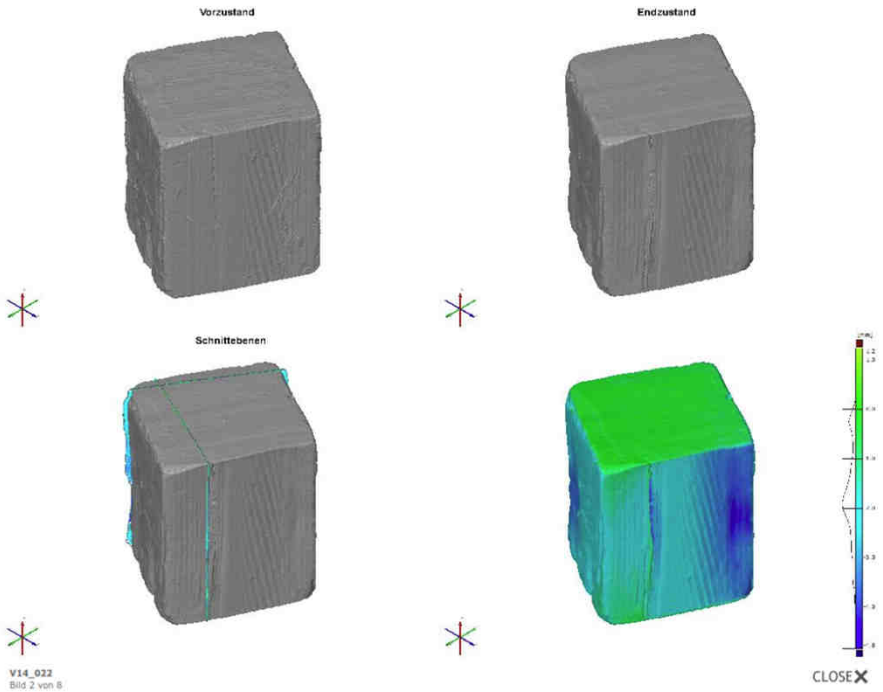
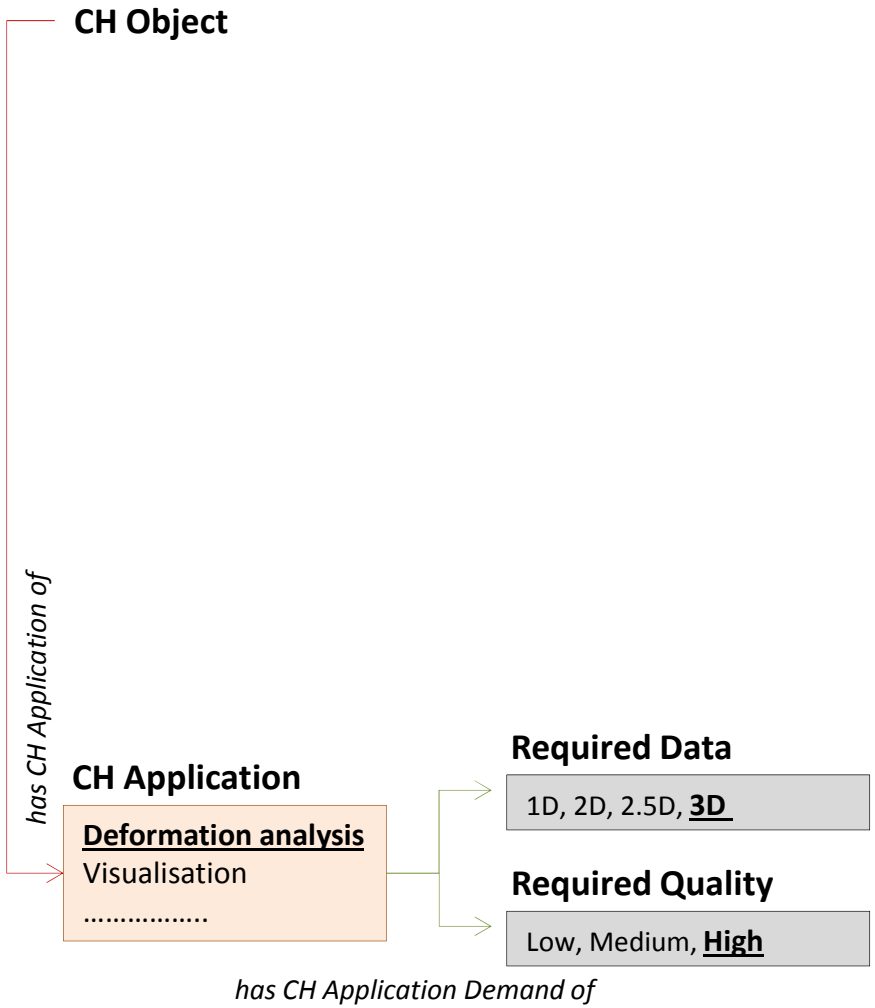
File Edit View Reasoner Tools Refactor Window Help
cosch (http://www.cosch.info/kb/cosch.owl)
Search for entity
Active Ontology Entities Classes Object Properties Data Properties Annotation Properties Individuals OWLViz DL Query OntoGraf Ontology Differences SPARQL Query
Class hierarchy Class hierarchy (inferred)
Class hierarchy: Structured_Light_3D_Scanner
Thing
Characterization
Entity
Applications
Data
ExternalInfluences
PhysicalThing
Technologies
BasicDataAcquisition
MeasurementSetups
Tools
HardwareDevices
InstrumentParts
MainOperatingInstruments
GPS
ImagingDevice
PointBasedRecorder
Projector
Scanner
LaserScanner
Structured_Light_3D_Scanner
TriangulationScanner
SoftwarePackages
SupportingAccessories
DataProcessing
MeasurementPrinciples
TechnicalProcess
Annotations Usage
Annotations: Structured_Light_3D_Scanner
Annotations
Description: Structured_Light_3D_Scanner
Equivalent To
hasOperatingNature only Active
(hasEssentials min 1 Camera)
and (hasEssentials exactly 1 Projector)
hasMeasurementPrinciples only TriangulationPrinciples
SubClass Of
(hasCost some High_Cost)
and (hasOperatingProject some
(Projects
and (hasProjectBudgetRange some High_Budget)))
hasSuitabilitiesFor some
(PhysicalThing
and ((hasObjectSize some 2DSize_Small)
or (hasObjectVolume some 3DVolume_Small)))
Scanner
SubClass Of (Anonymous Ancestor)
hasGenerationOnData only BasicData
hasOperatingNature only OperatingNature
hasMeasurementPrinciples some MeasurementPrinciples
(hasGenerationOnData some
(3D_Data
and (hasLocalSpatialDataAccuracy some
(AlignedAcBgSz_Low-in-3D
or AlignedAcMdSz_Low-in-3D
or AlignedAcSzSm_Low-in-3D))))
and (hasOperatingOnObject some
(PhysicalThing
and (hasObjectReflectance some High_Reflectivity)))
(hasGenerationOnData some
(3D_Data
and (hasLocalSpatialDataAccuracy some
(AlignedAcBgSz_Medium-in-3D
or AlignedAcMdSz_Medium-in-3D
or AlignedAcSzSm_Medium-in-3D))))
and (hasOperatingOnObject some
(PhysicalThing
and (hasObjectReflectance some Moderate_Reflectivity)))
No Reasoner set. Select a reasoner from the Reasoner menu
Show Inferences

Simulation of a GUI

- Spatial Case Study: Deformation analysis
  - Creation of 3D-models of waterlogged wood to determine and visualise the spatial differences before and after conservation treatment.




CH Object
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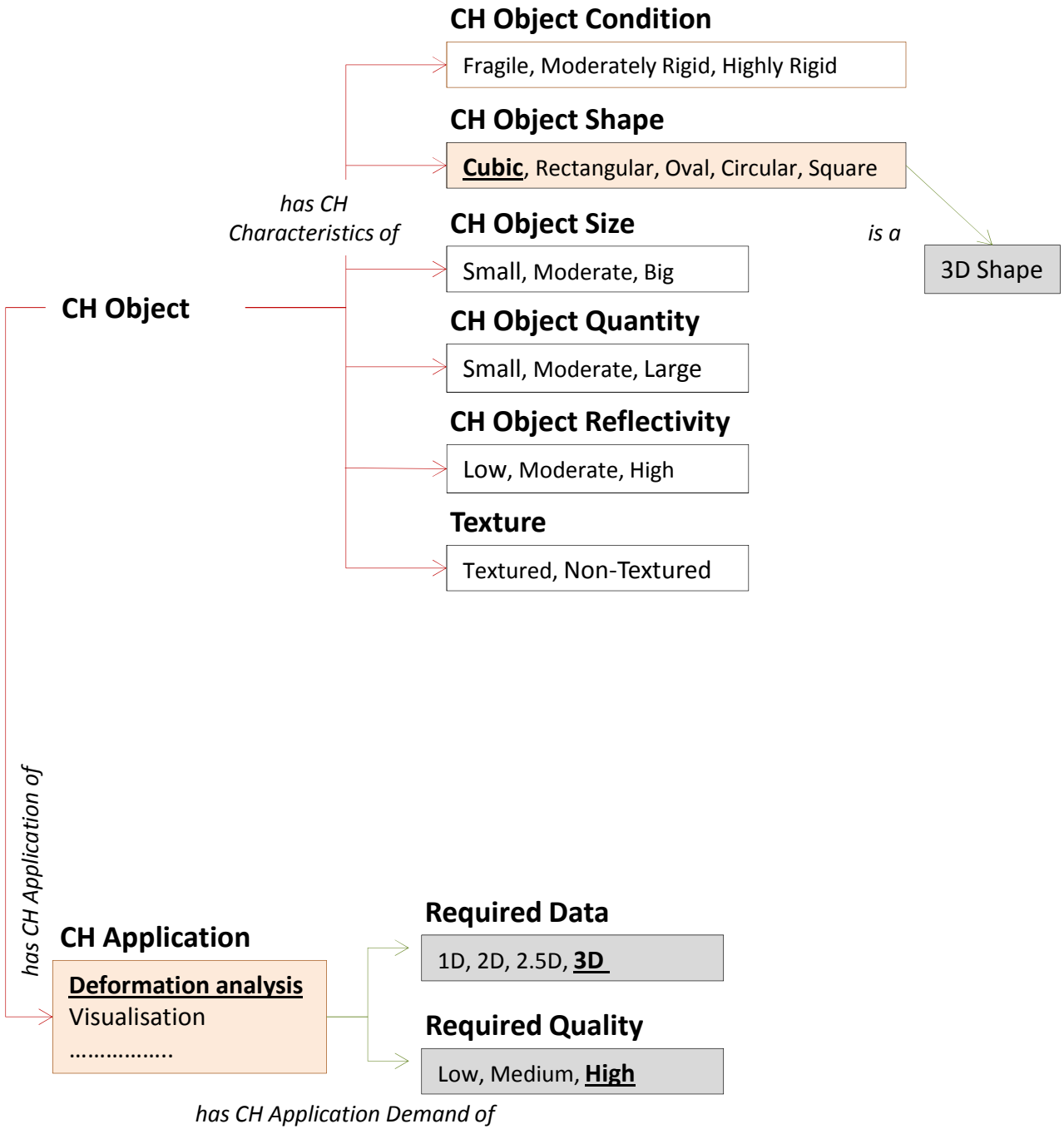
……..
Required Data
1D, 2D, 2.5D, 3D
Required Quality
Low, Medium, High
has CH Application Demand of


CH Object Condition
Fragile, Moderately Rigid, Highly Rigid
CH Object Shape
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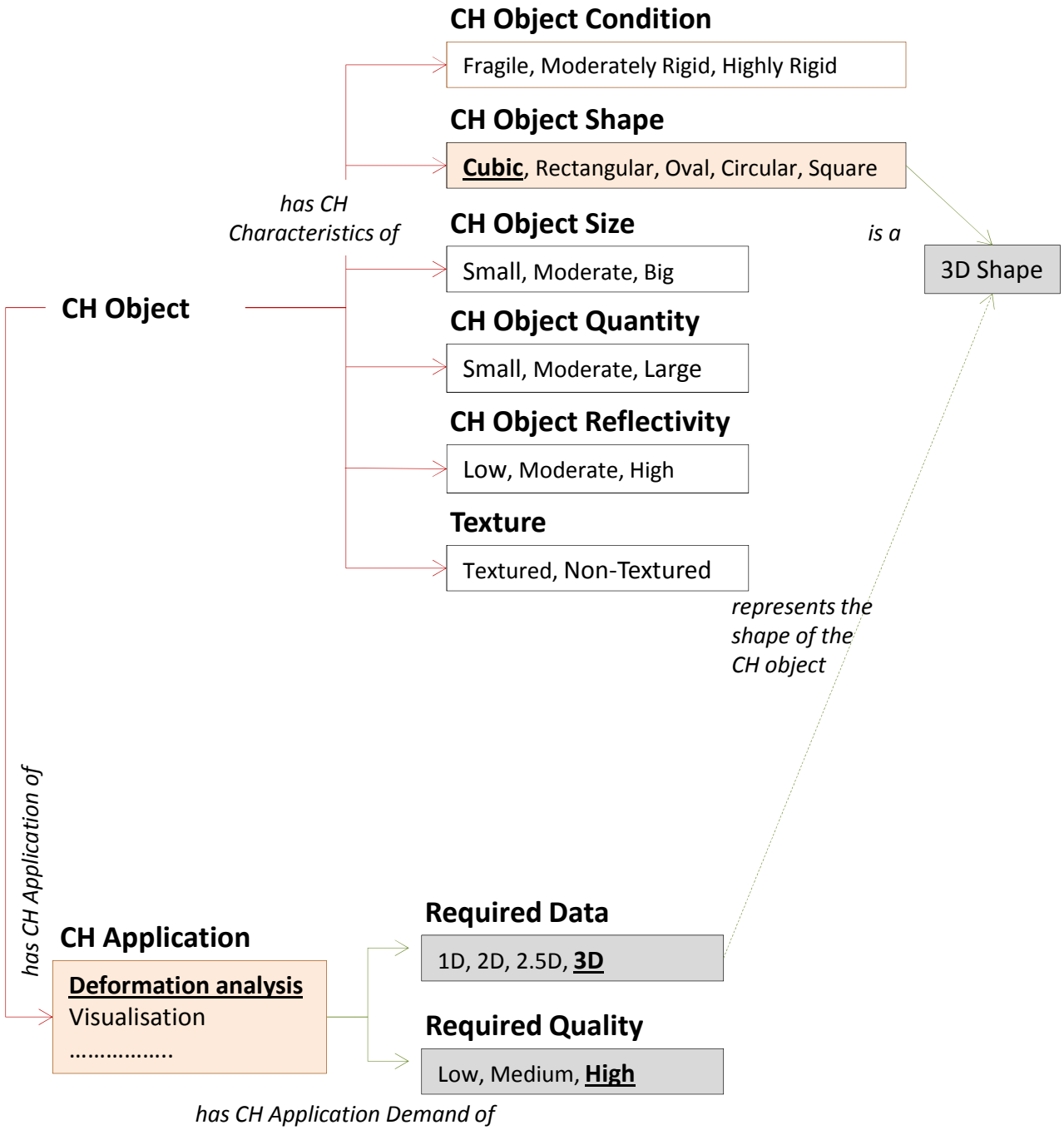
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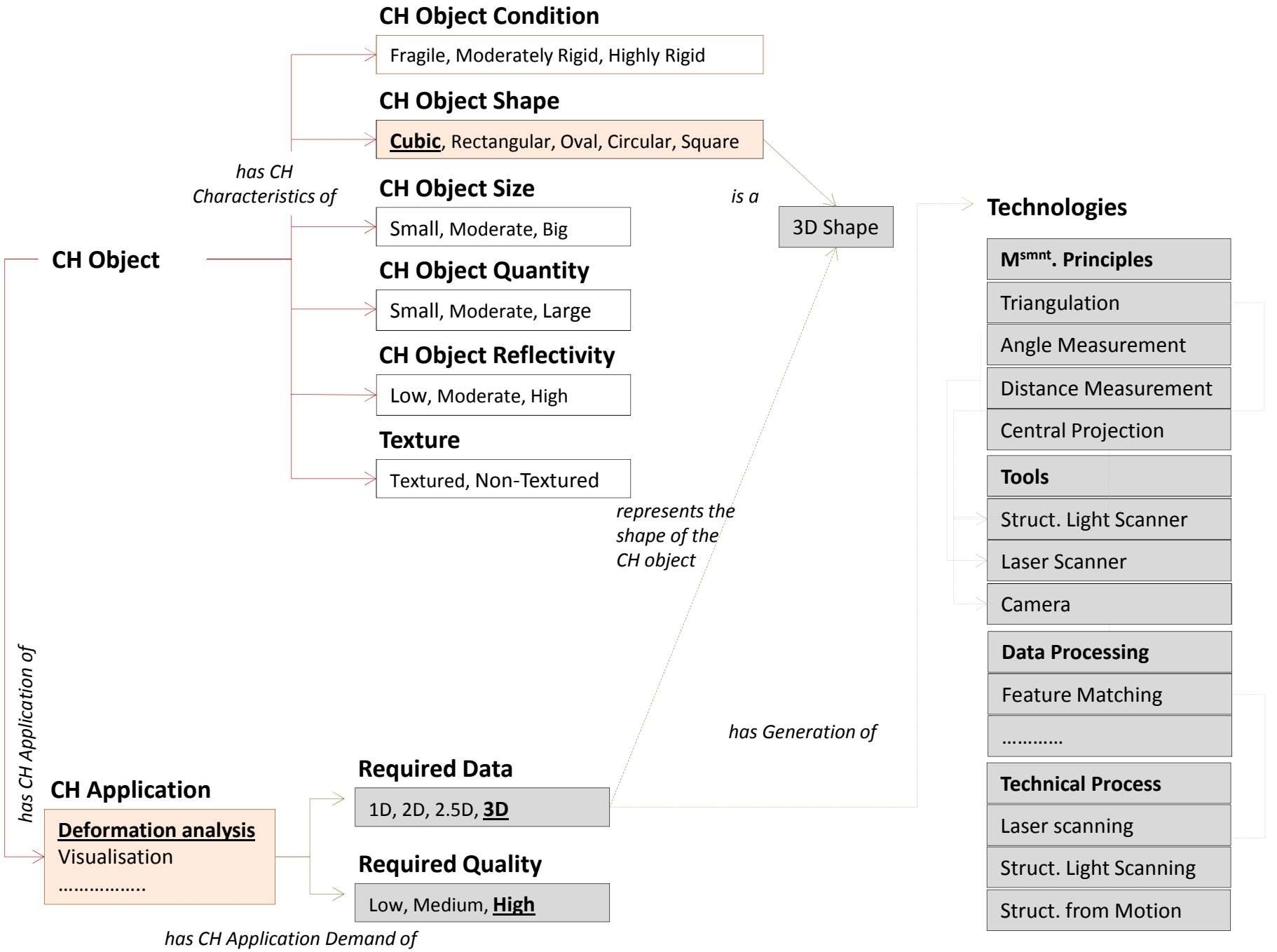
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Msmnt. Principles
Triangulation
Angle Measurement
Distance Measurement
Central Projection
Tools
Struct. Light Scanner
Laser Scanner
Camera
Data Processing
Feature Matching
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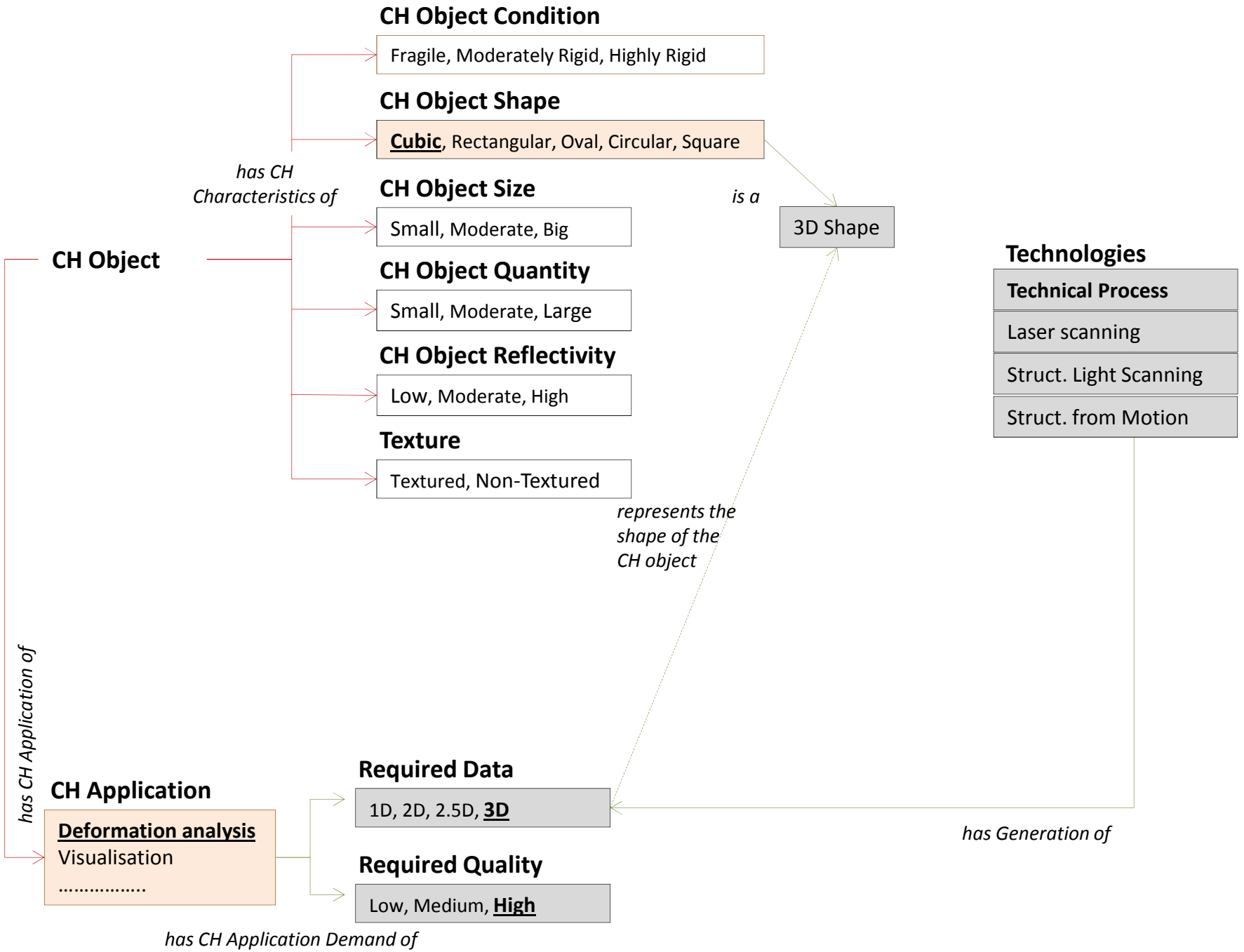
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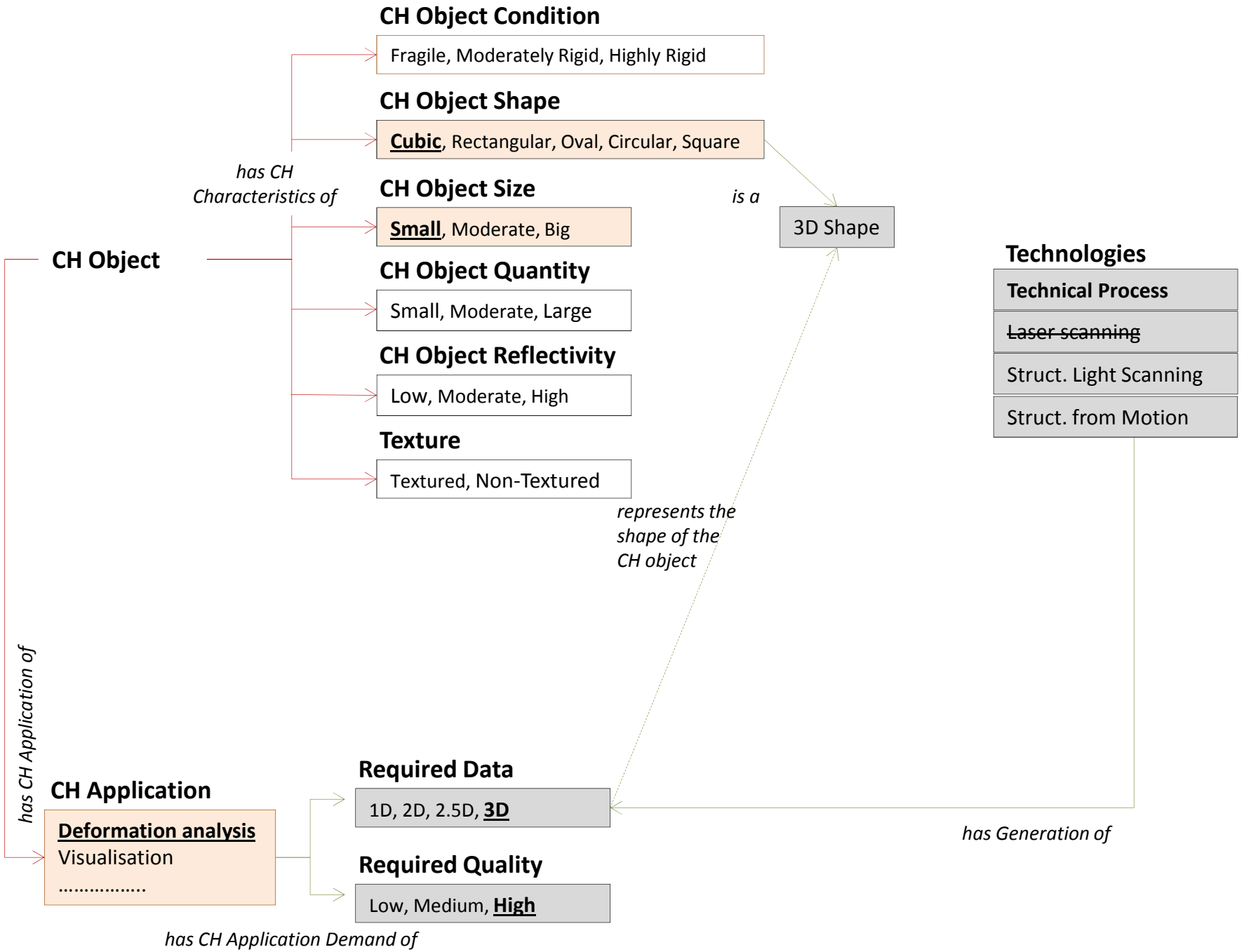
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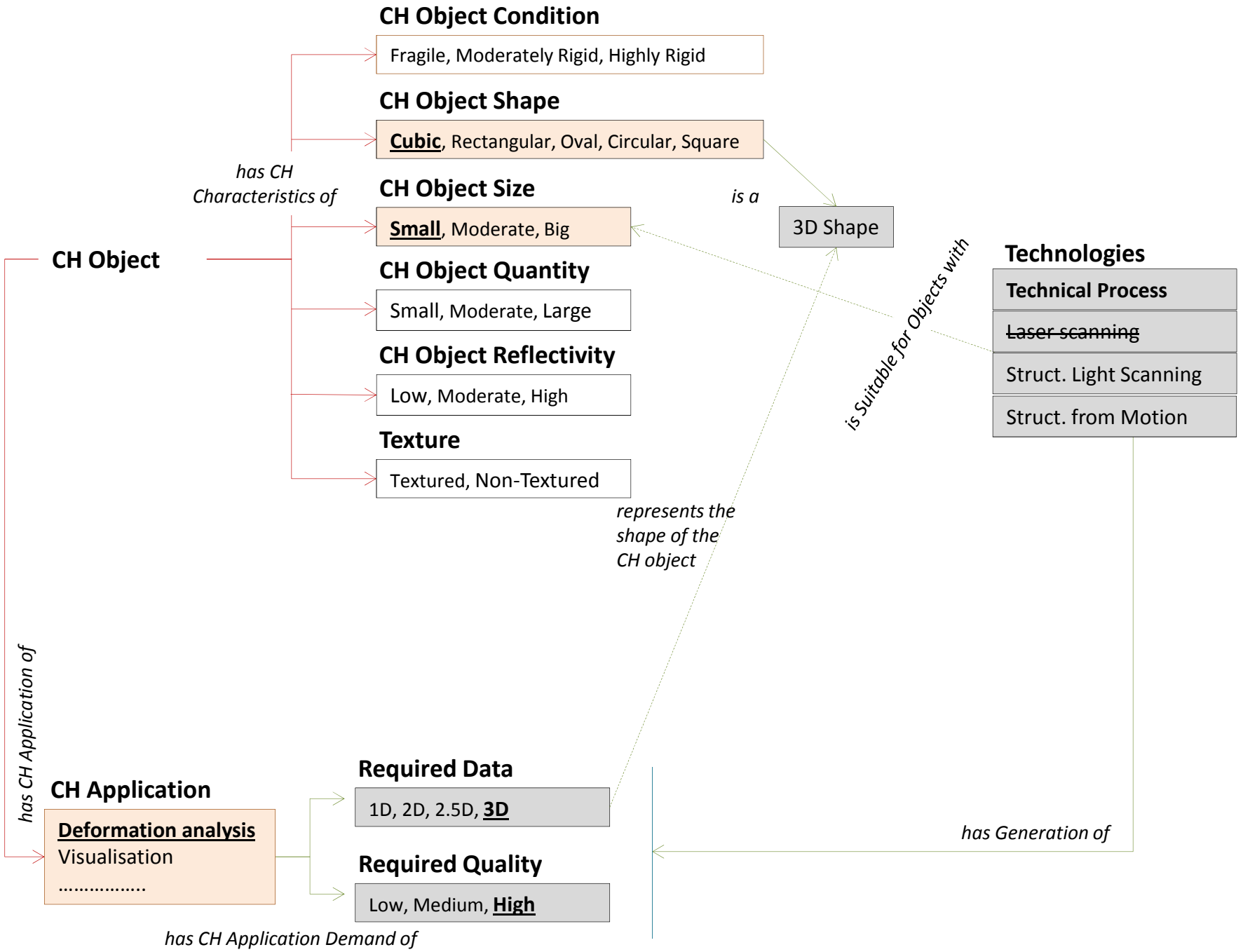
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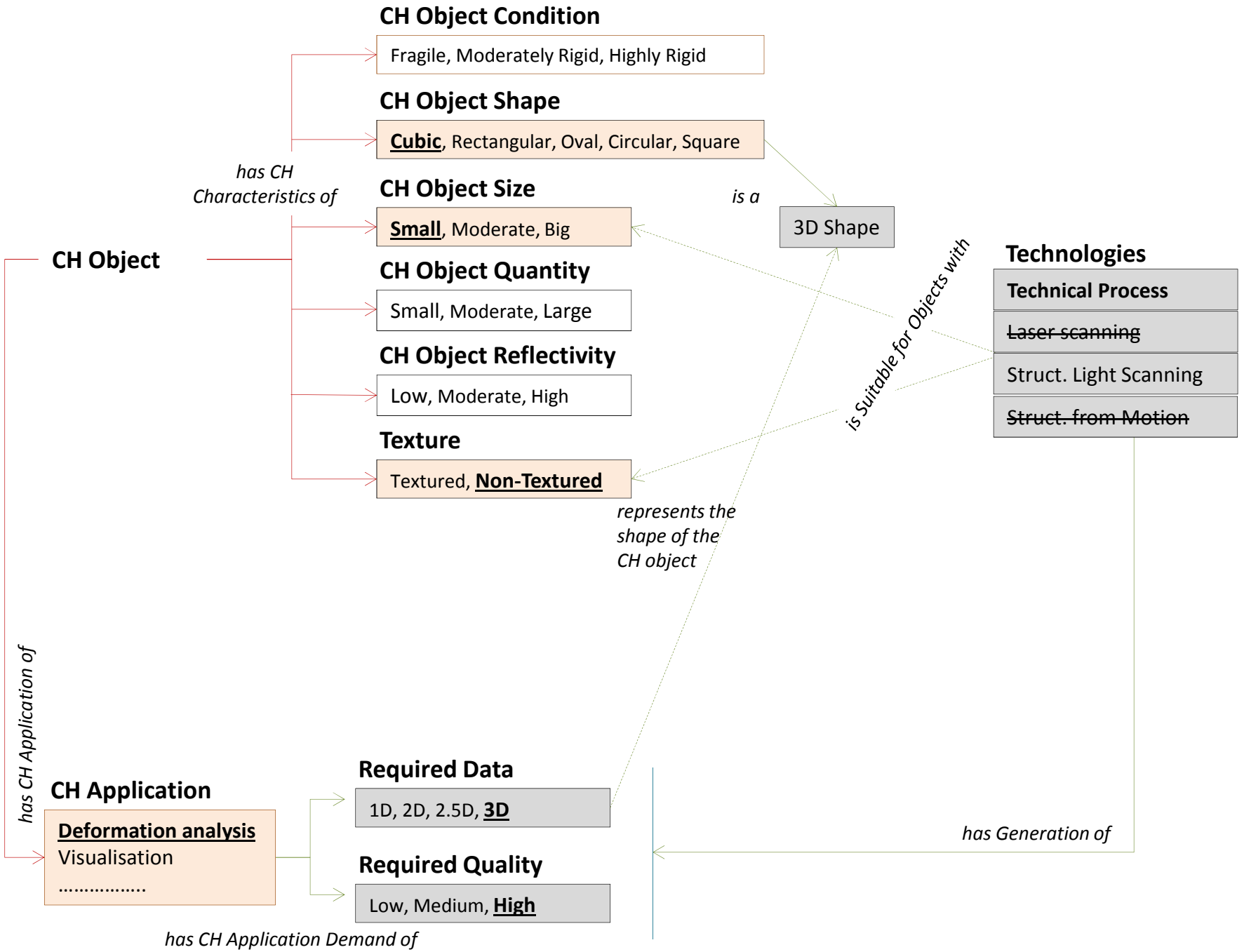
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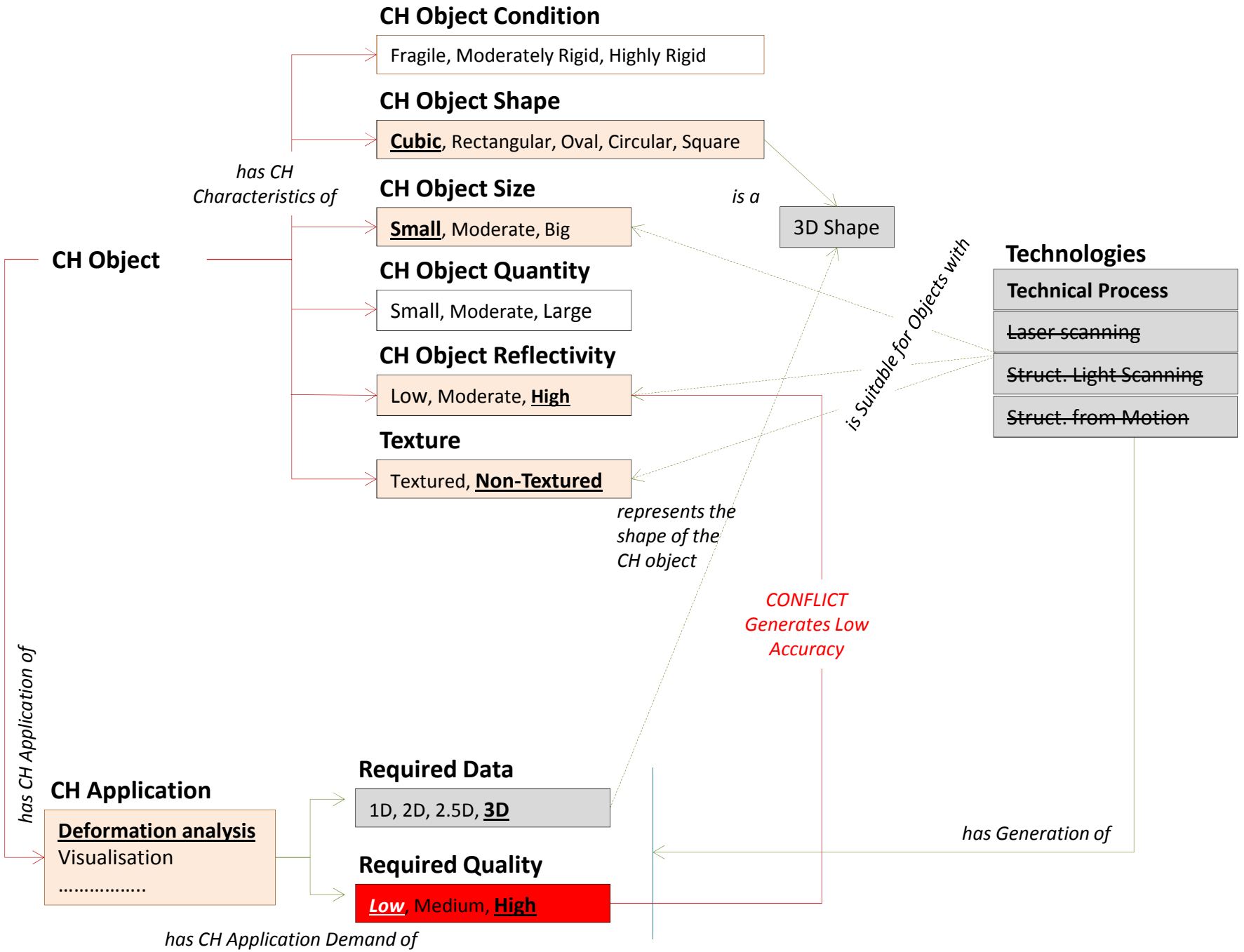
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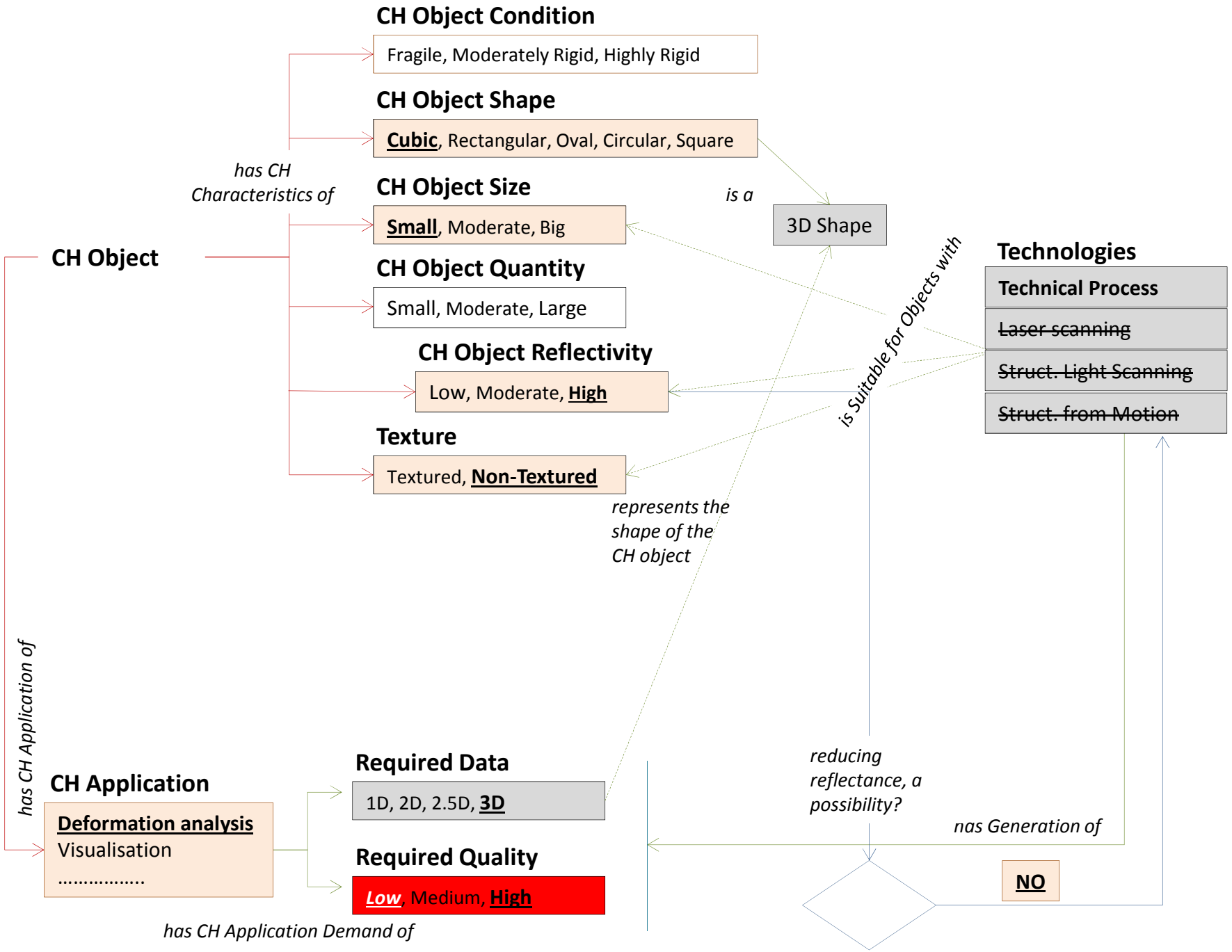
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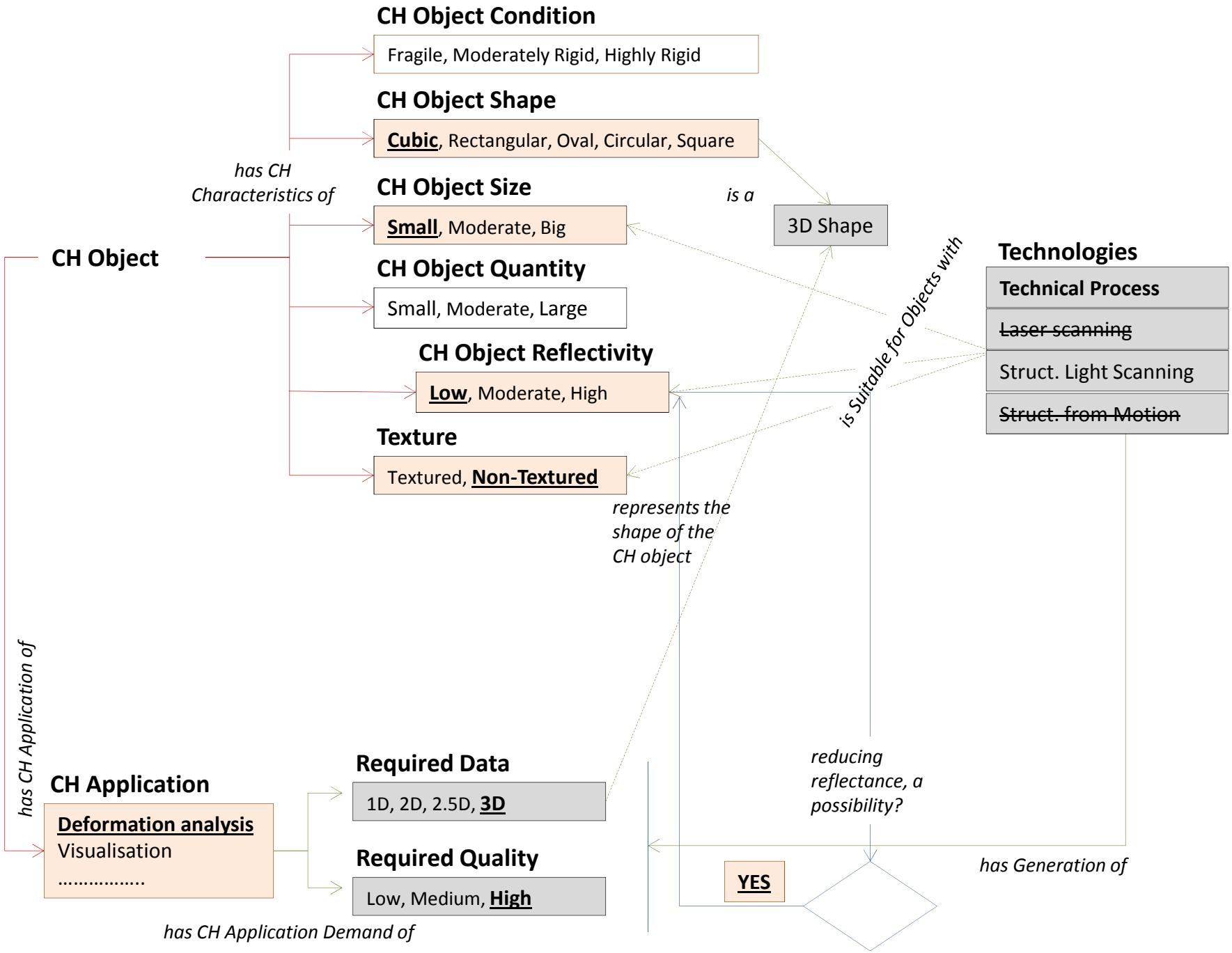
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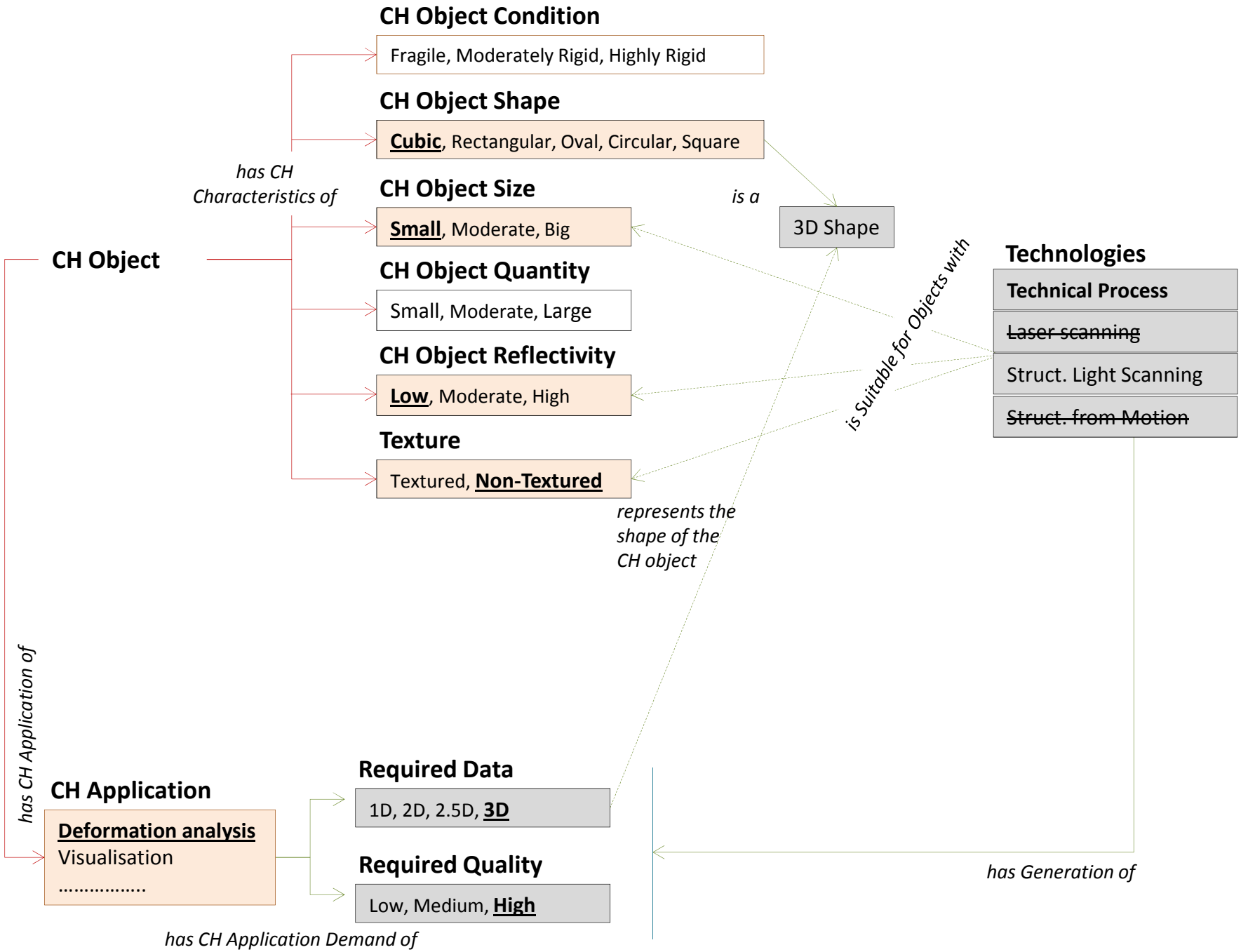
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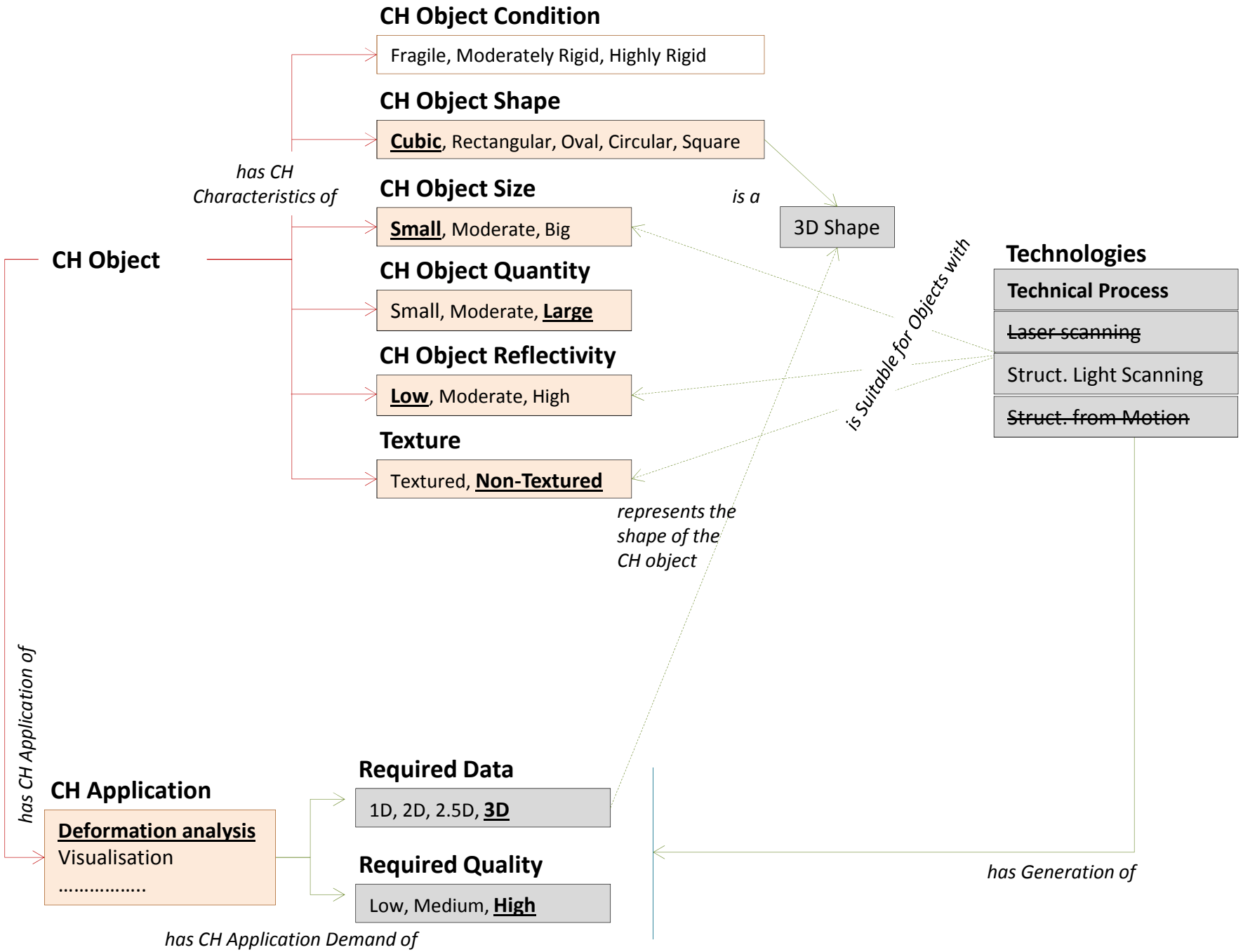
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Required Quality
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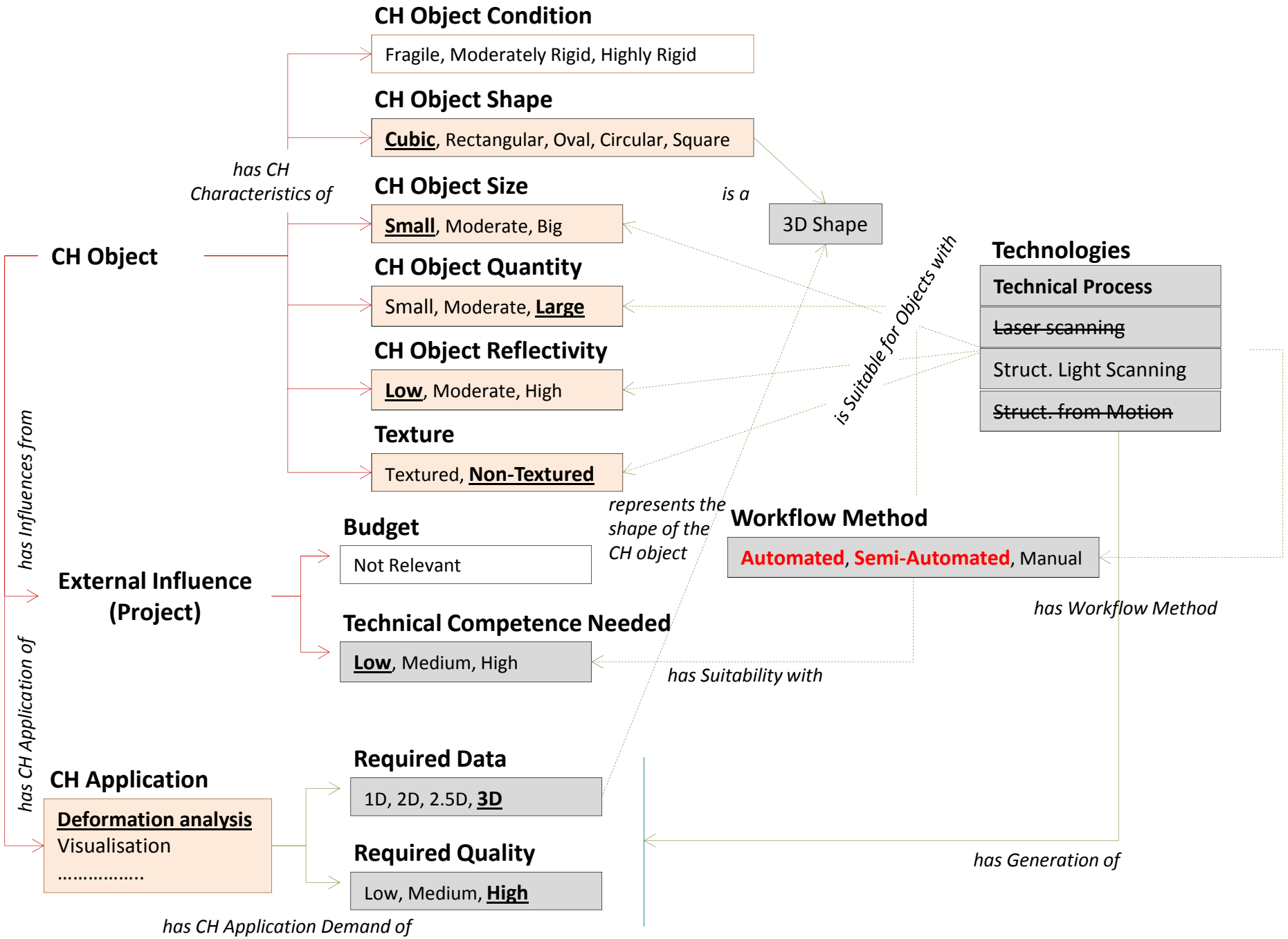
has CH Application Demand of
has Generation of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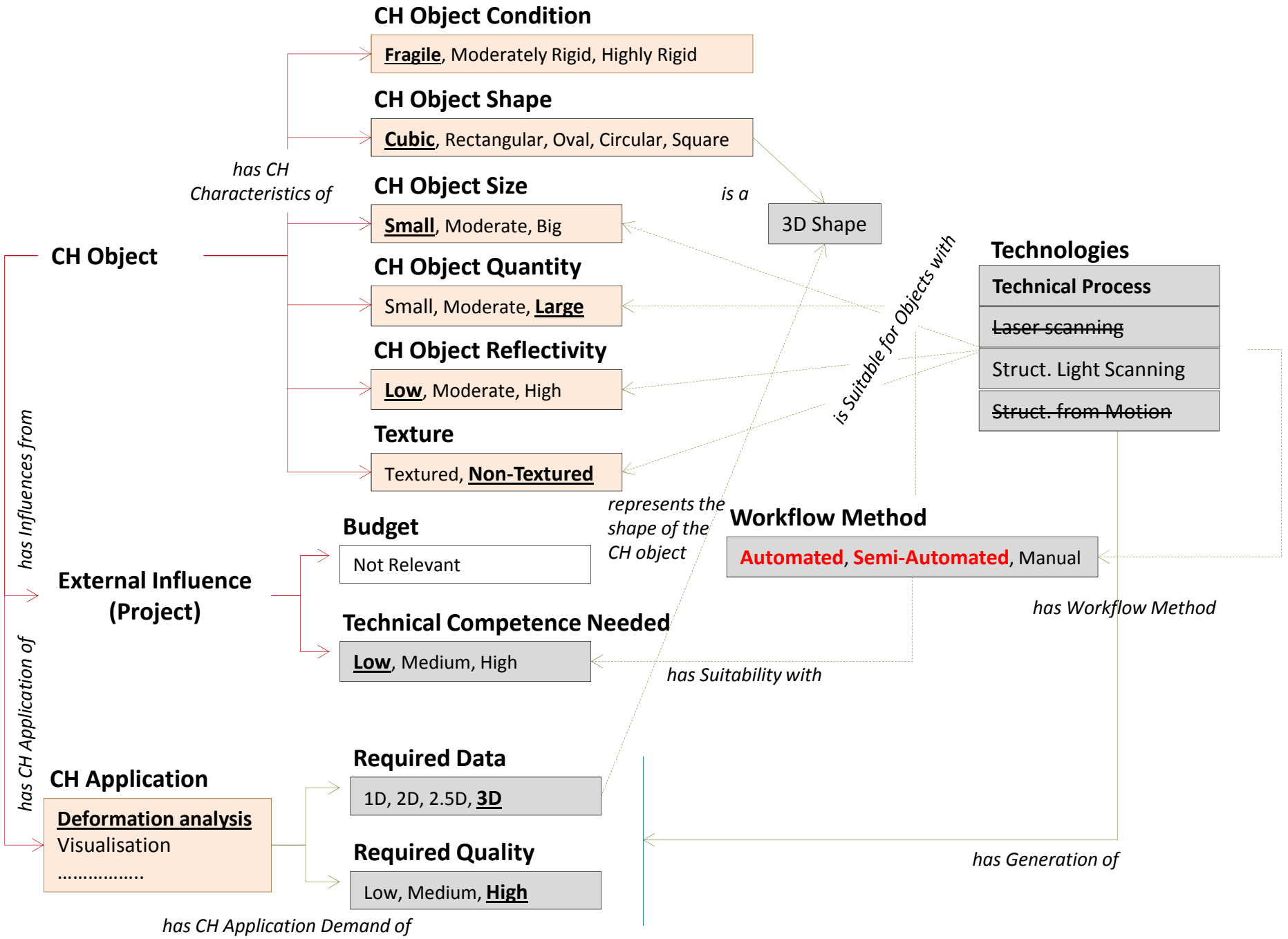
Texture
Textured, Non-Textured
Technologies
Technical Process
Laser scanning
Struct. Light Scanning
Struct. from Motion
is Suitable for Objects with
represents the shape of the CH object
Workflow Method
Automated, Semi-Automated, Manual
has Workflow Method
has Influences from
Budget
Not Relevant
External Influence (Project)
Technical Competence Needed
Low, Medium, High
has Suitability with
has CH Application of
Required Data
1D, 2D, 2.5D, 3D
CH Application
Deformation analysis
Visualisation
.....
Required Quality
Low, Medium, High
has Generation of
has CH Application Demand of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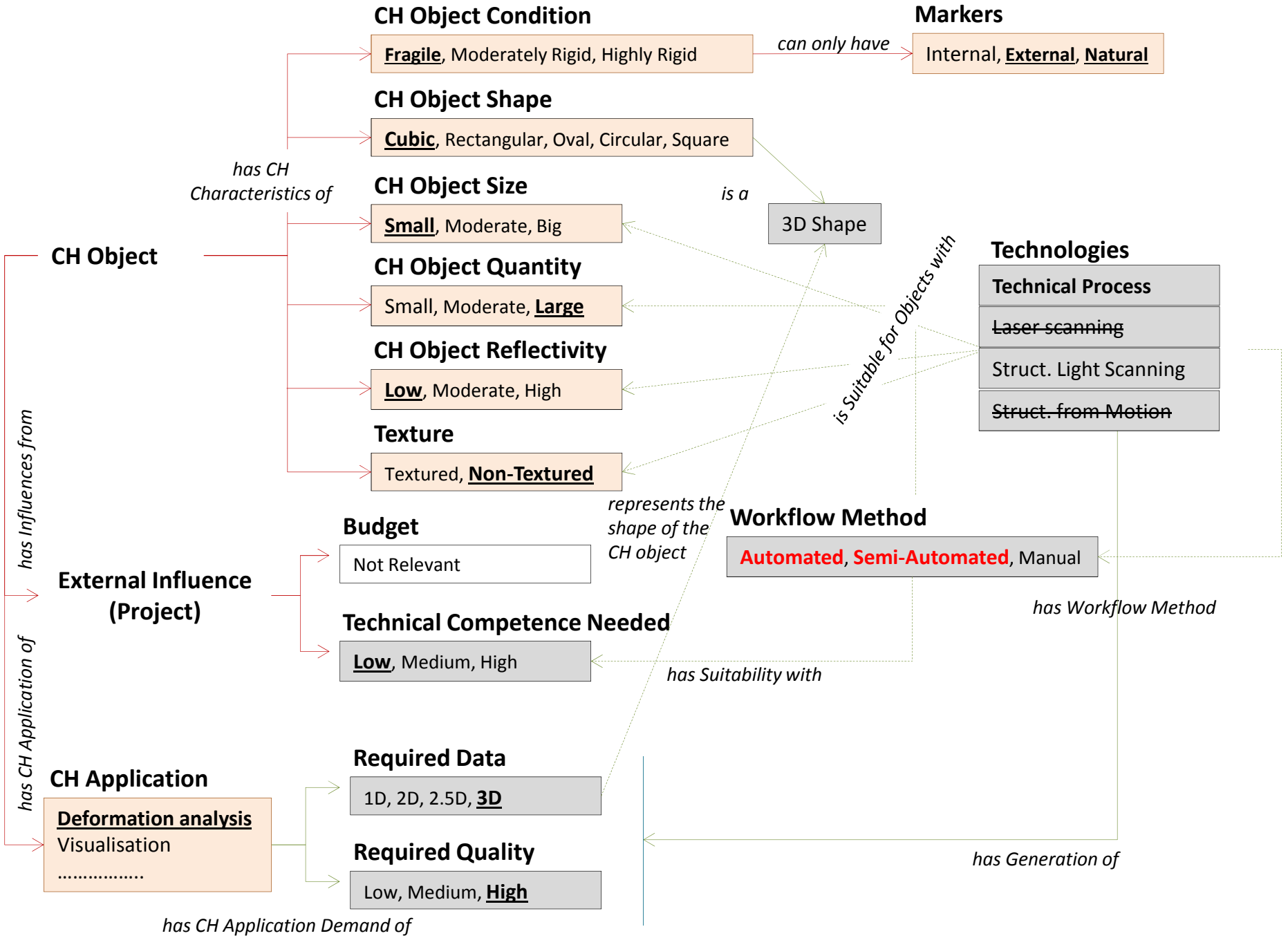
CH Object Size
Small, Moderate, Big
CH Object
CH Object Quantity
Small, Moderate, Large
CH Object Reflectivity
Low, Moderate, High
Texture
Textured, Non-Textured
Technologies
Technical Process
Laser scanning
Struct. Light Scanning
Struct. from Motion
is Suitable for Objects with
represents the shape of the CH object
Workflow Method
Automated, Semi-Automated, Manual
has Workflow Method
has Influences from
Budget
Not Relevant
External Influence (Project)
Technical Competence Needed
Low, Medium, High
has Suitability with
has CH Application of
Required Data
1D, 2D, 2.5D, 3D
CH Application
Deformation analysis
Visualisation
.....
Required Quality
Low, Medium, High
has Generation of
has CH Application Demand of


CH Object Condition
Fragile, Moderately Rigid, Highly Rigid
can only have
Markers
Internal, External, Natural
CH Object Shape
Cubic, Rectangular, Oval, Circular, Square
has CH Characteristics of
is a
3D Shape
CH Object Size
Small, Moderate, Big
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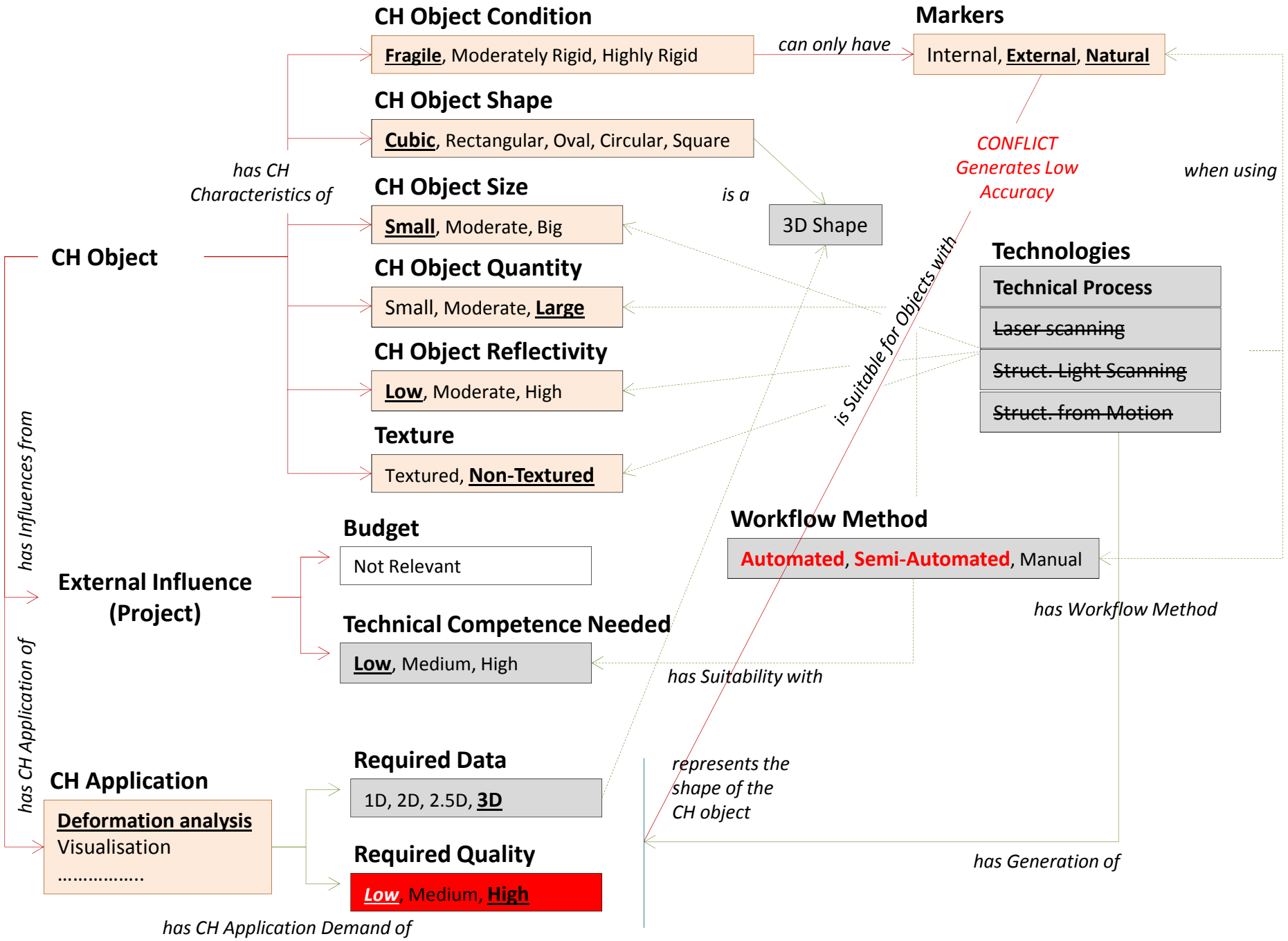
CH Object Condition
Fragile, Moderately Rigid, Highly Rigid
can only have
Markers
Internal, External, Natural
CH Object Shape
Cubic, Rectangular, Oval, Circular, Square
CONFLICT
Generates Low
Accuracy
when using
has CH
Characteristics of
is a
3D Shape
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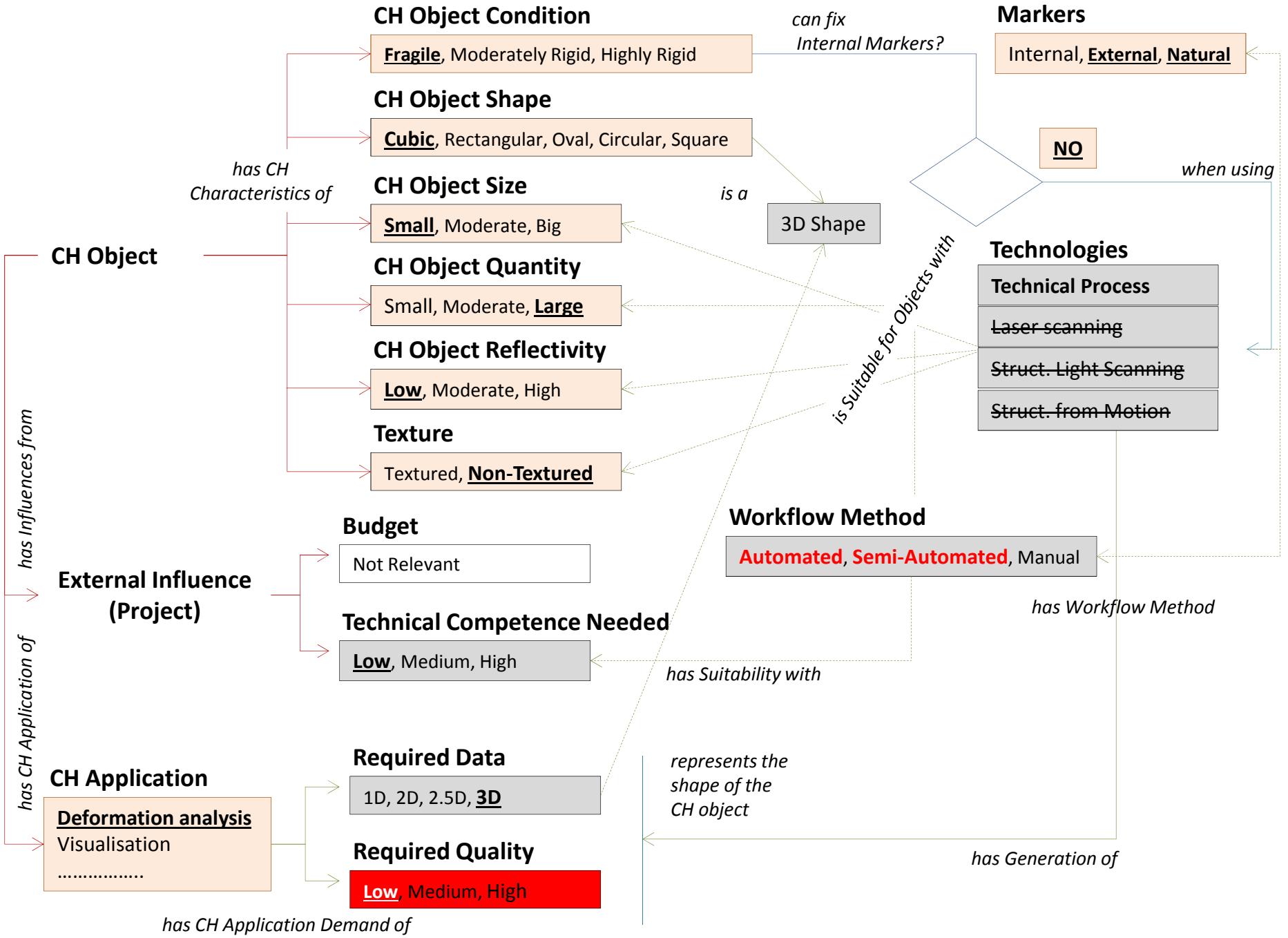
CH Object Condition
Fragile, Moderately Rigid, Highly Rigid
can fix Internal Markers?
Markers
Internal, External, Natural
CH Object Shape
Cubic, Rectangular, Oval, Circular, Square
NO
when using
has CH Characteristics of
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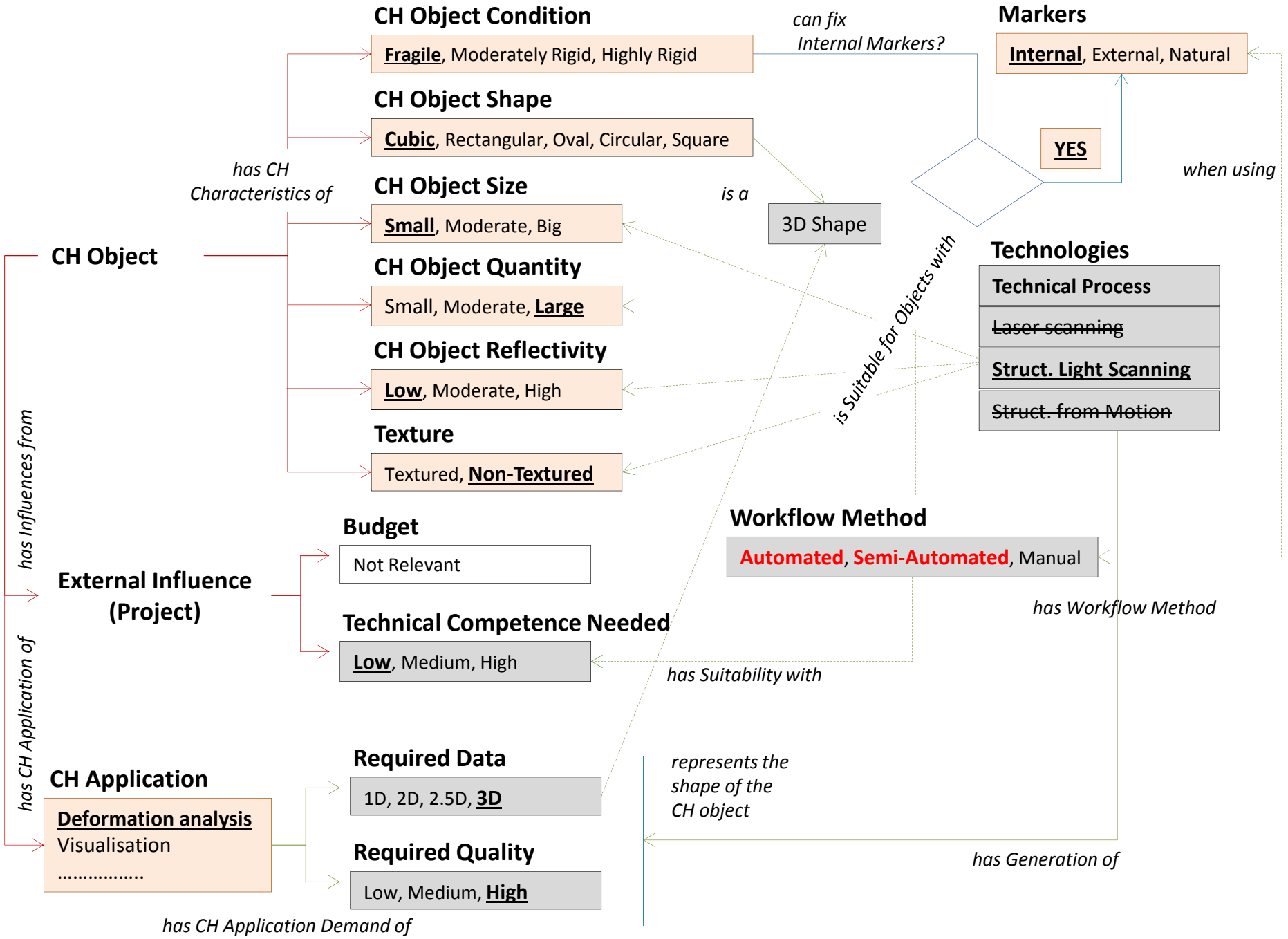
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when using
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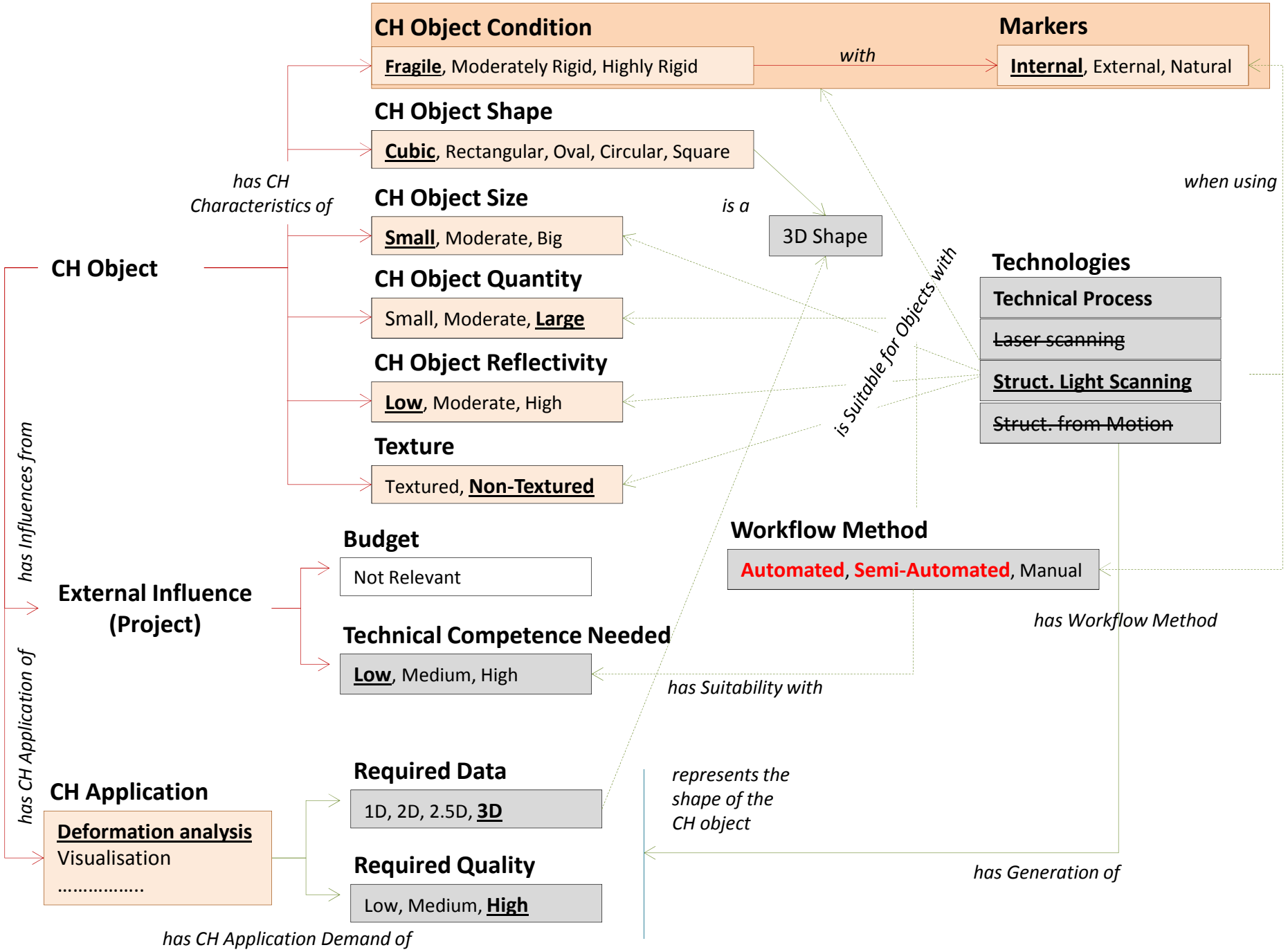
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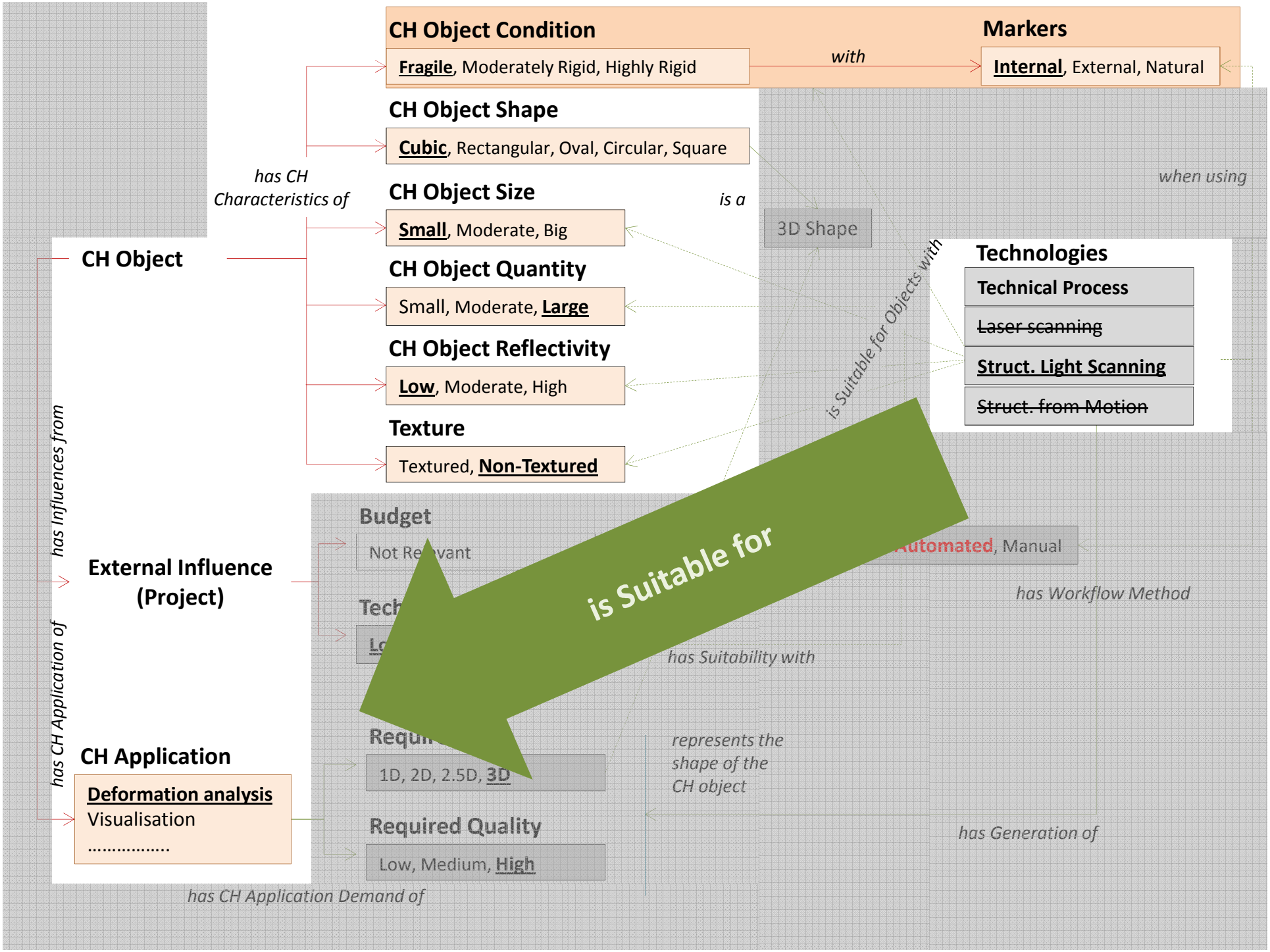
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Status quo and future perspective

- CH Applications „deformation analysis“ (spatial) and „revelation of underdrawing“ (spectral) operable through the created ontology
  - more than 750 classes
  - Laser Scanning is partially included as an alternative approach
- Another spectral CH Application will be designed (Tatiana PhD topic)
- Further CH Applications will be implemented (even after COSCH)
- Ontology will be published in the near future through a front end using a **Prolog Inference Mechanism**

Prolog Inference Mechanism

- Under development in collaboration with MISANU colleagues from Belgrade
- COSCH^{KR} ontology is parsed to infer and discover knowledge for optimal recommendations
- A web service will be developed with an interactive interface (front-end) and COSCH^{KR} + inference mechanism (back-end)

Challenges

- Common understanding:
  - interdisciplinary understanding
  - remote discussions versus face-to-face discussions
- Discipline habits/methods have to be broken down into logically linked pieces
- Every single piece has to be named, structured, and linked
  - Example: text > chapter > paragraph > phrase > word > letter

In a long-term perspective,
the entire CH community will benefit from COSCH^{KR} platform
as digitisation projects, which rely on COSCH^{KR} recommendations,
will be more sustainable and durable.

Thank you for your attention!

Publications:

- A. Karmacharya, St. Wefers, F. Boochs, Knowledge Based Recommendation on Optimal Spectral and Spatial Recording Strategy of Physical Cultural Heritage Objects. Proceedings Semapro 2016.
- M. Pfarr-Harfst, St. Wefers, Digital 3D reconstructed models – Structuring visualisation project workflows. Proceedings EuroMed 2016.
- St. Wefers, A. Karmacharya, F. Boochs, Development of a platform recommending 3D and spectral digitisation strategies. Virtual Archaeology Review 7 (15), 2016.
- A.-K. Wiemann, F. Boochs, A. Karmacharya, St. Wefers, Characterisation of Spatial Techniques for Optimised Use in Cultural Heritage Documentation. In: M. Ioannides et al. (eds.), Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection. Proceedings of the 5th International Conference, EuroMed 2014, Limassol, Cyprus, November 3-8, 2014. Lecture Notes in Computer Science 8740, 374-386.

in preparation:

- A. Karmacharya, St. Wefers, Structuring spectral and spatial recording strategies of cultural heritage assets - Background, state of affairs, and future perspectives. COSCH final book.
- M. Pfarr-Harfst. St. Wefers, F. Boochs, A. Karmacharya, Digital 3D reconstructed models – Structuring project workflows using semantic technologies to develop recommendations. Proceedings Conference on Cultural Heritage and New Technologies November 16-18, 2016, Vienna, Austria.

planned:

- Semantic reasoning
- Spectral case study

Inference system through Prolog

- Ontologies
  - optimal tool for knowledge representation
  - represents **WHAT** on a subject and not **HOW**
    - Example:
      - **Structured Light Scanning** is defined through Structured Light Scanner, data it generates, a setup and a data processing – this is WHAT
      - BUT there are OTHER number of ways Structured Light Scanning works and they are HOWs. These HOWs are encrypted in COSCH^{KR} within single classes through rules.
      - Prolog is versed in managing these situation based HOWs.