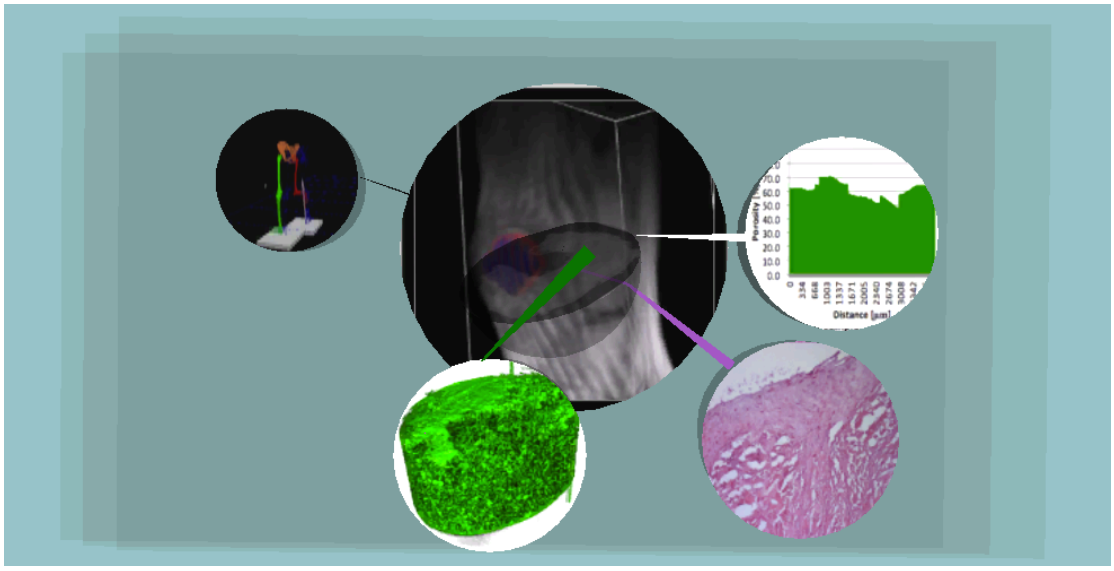
Supplementary material

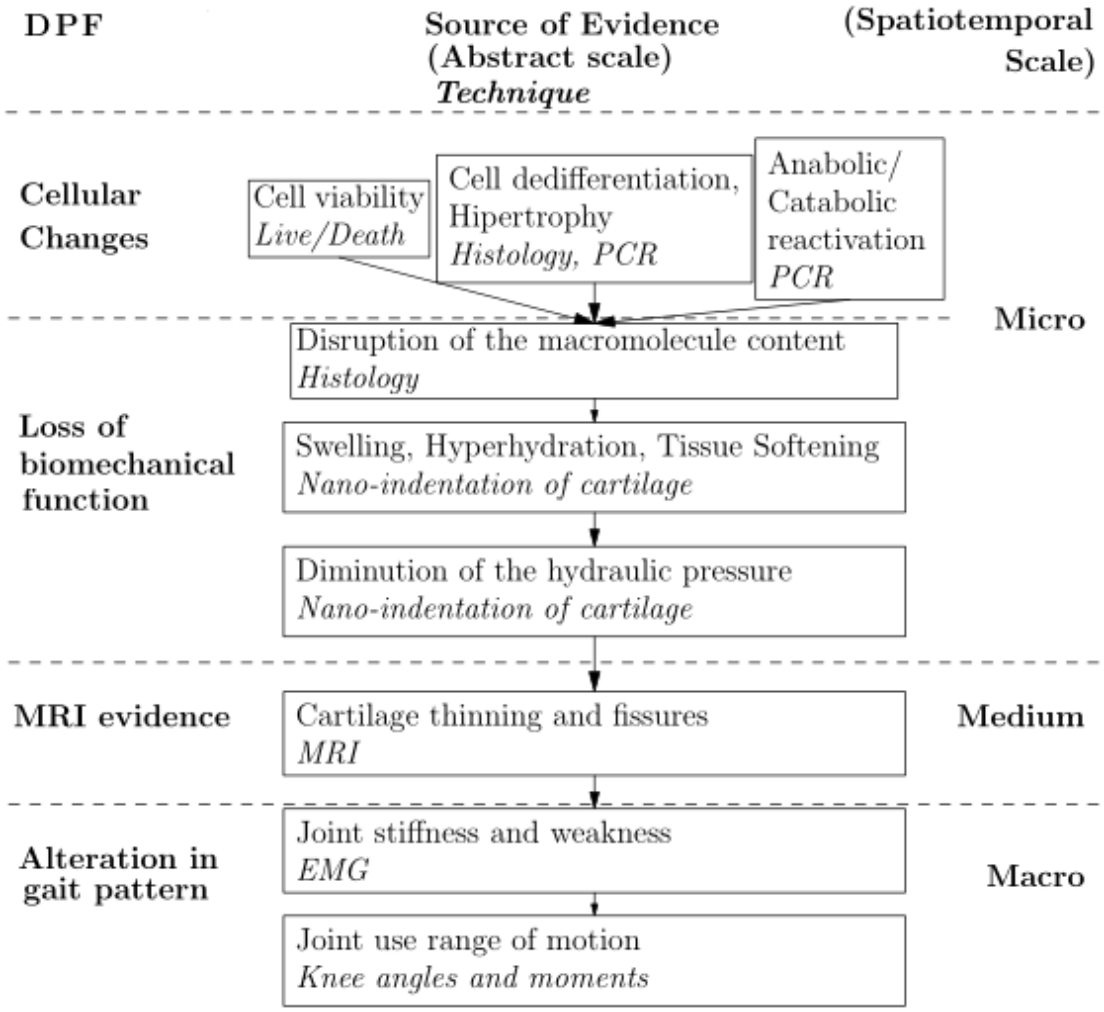
Bigger figures with bigger captions to explain better the visualization framework. More "in-depth" explanation on Knowledge formalization and querying.

Proposed visualization framework



Proposed visualization framework, with micro- scale as main scale. On the Focus layer (F) there are several nodes: The 3D reconstruction of micro-CT scan of meniscus points to the CT of meniscus of analysis. The same is valid for the histological section of a meniscus, which points to the section of the meniscus of analysis. The graph represents the longitudinal porosity of the meniscus, which points to the surface of the node. On the Context layer (C), there is just the 3D representation of knee, which is spatially aligned with the Focus (CT of meniscus). Finally, on the Background layer (B), least seen and less important for the user, the gait pattern animation is presented by using the call-out technique, alleviating the differences in the order of magnitude and completing the general view across all the spatiotemporal ranges.

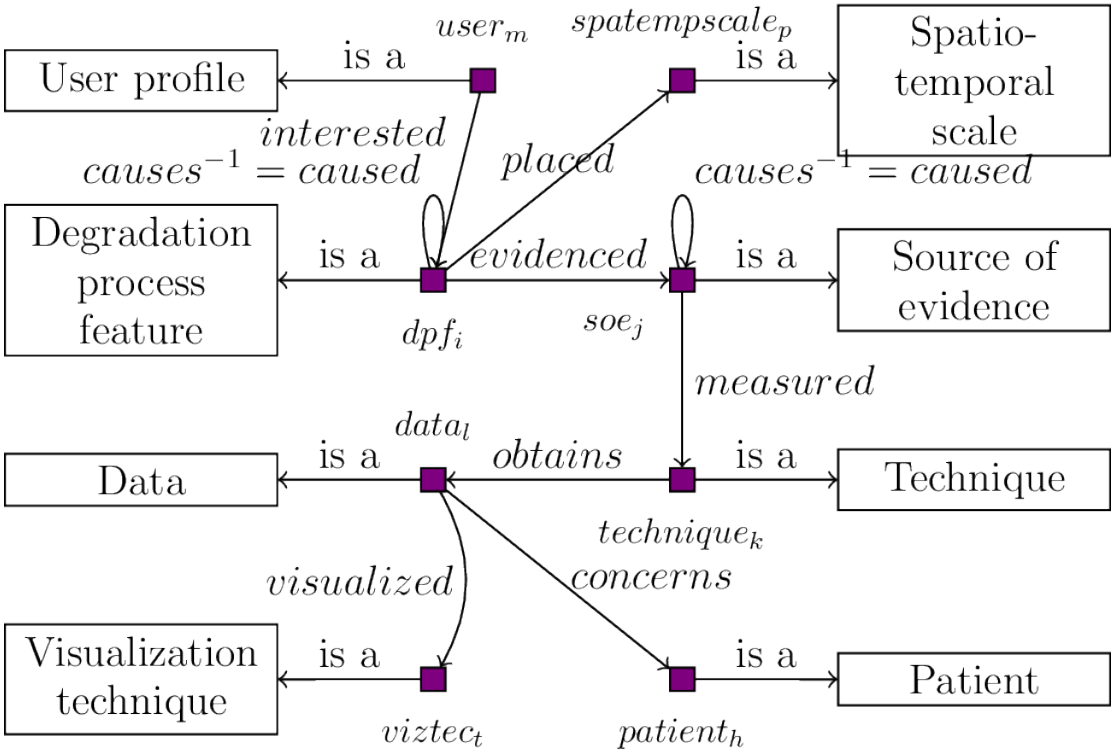
Degradation process during osteoarthritis



Chondrocytes death, dedifferentiation and hypertrophy or catabolic/ anabolic reactivation can cause the disruption of the macromolecules content and increase the extracellular matrix permeability. These evidences can be obtained through analysis of cross-sectional histology and cell viability assays. The disease on macromolecular scale increases the compressive stiffness and softening of the cartilage, evidenced by variations on the mechanical properties with the nano-indentation technique, and leads to a mechanical overloading. The consequence of this overloading can be observed in MRI as thinning and progressive loss of cartilage. Finally, this degenerative process reaches the gait pattern, causing

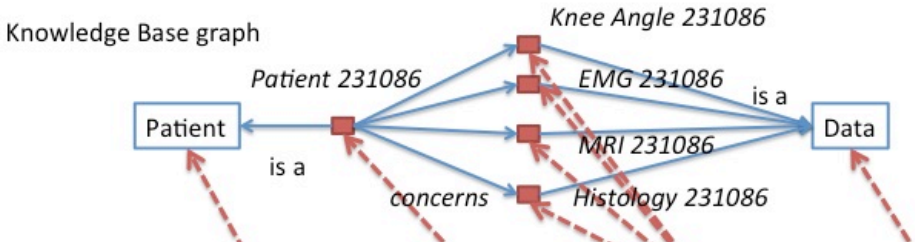
weakness or over activation of certain surrounded muscles, evidenced by EMG. These facts leads to variations of joint stiffness and range of motion of the knee.

Knowledge formalization of M

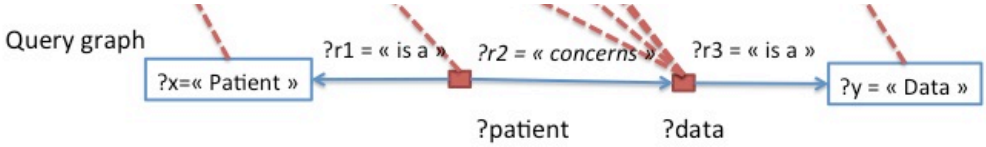


Graph pattern matching and query evaluation

Knowledge Base of our Integrated Visualization is formalized by using an OWL Ontology encoded in the RDF graph data model. For example an excerpt of our Knowledge Base expressed in English as:
"*Patient 231086* is a **Patient** which *concerns* the following **Data**: *MRI 231086, EMG 231086, Knee Angle 231086, Histology 231086*" would look like the following image as an RDF graph:

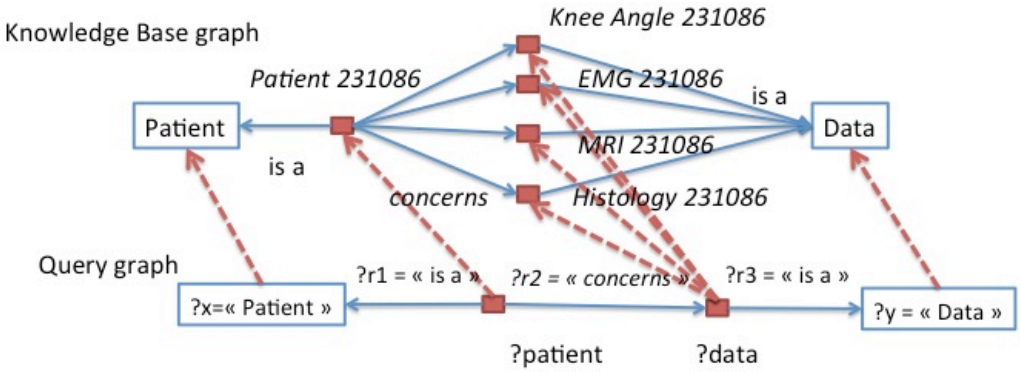


The query expressed in English as: "Which are all the **Data** that **Patient** *Patient 231086* **concerns**?" would look like the following image as an RDF graph:



Please do note that this RDF graph ("Query graph") contains "variables" that may be bound to a value, or unbound (i.e. may take any value). For instance the variables *"?x", "?r1", "?r2", "?r3"* are bound to values *"Patient", "is a", "concerns", "is a"* respectively. In other words these bound variables may only match nodes in the Knowledge Base graph that have the same values (i.e. labels). However the variables *"?patient"* and *"?data"* are unbound, therefore may match any node with any value (label) as long as the overall structure is preserved.

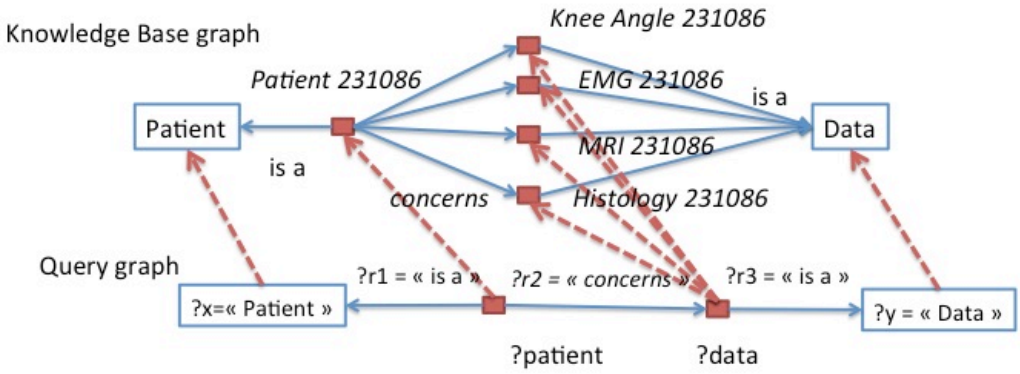
SPARQL evaluates queries from a Query graph to the Knowledge Base graph, by using graph pattern matching techniques.



The image above is an example of a graph pattern match from the "Query graph" to the "Knowledge Base graph". Note that bound variables were matched exactly ones and to the nodes with the same value. Also note that since the variable *"?data"* is unbound, then it could be matched to any of the *"Knee Angle 231086", "EMG 231086", "MRI 231086", "Histology 231086"*. Therefore there are four possible pattern matches:

?x	?r1	?patient	?r2	?data	?r3	?y
Patient	*Is a*	*Patient 231086*	*concerns*	*Knee Angle 231086*	*Is a*	*Data*
Patient	*Is a*	*Patient 231086*	*concerns*	*EMG 231086*	*Is a*	*Data*
Patient	*Is a*	*Patient 231086*	*concerns*	*MRI 231086*	*Is a*	*Data*
Patient	*Is a*	*Patient 231086*	*concerns*	*Histology 231086*	*Is a*	*Data*

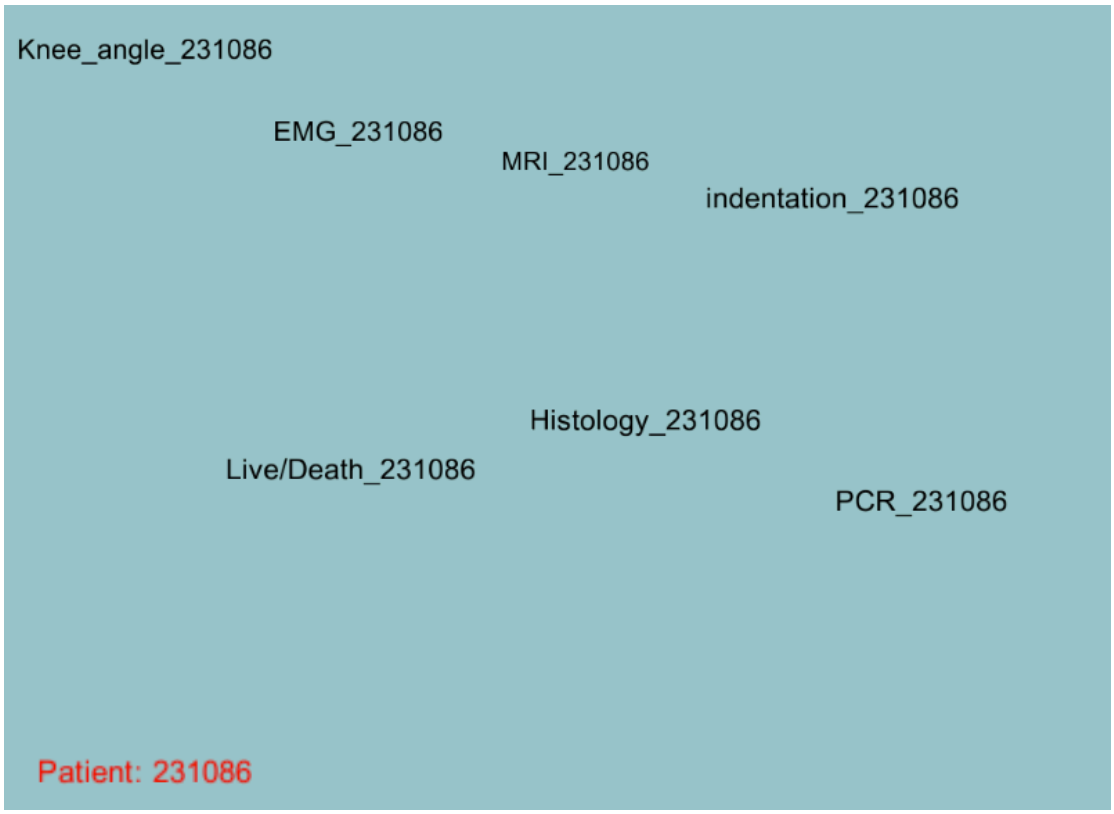
These four posible matches correspond to all the data that **Patient** *Patient 231086* **concerns**.



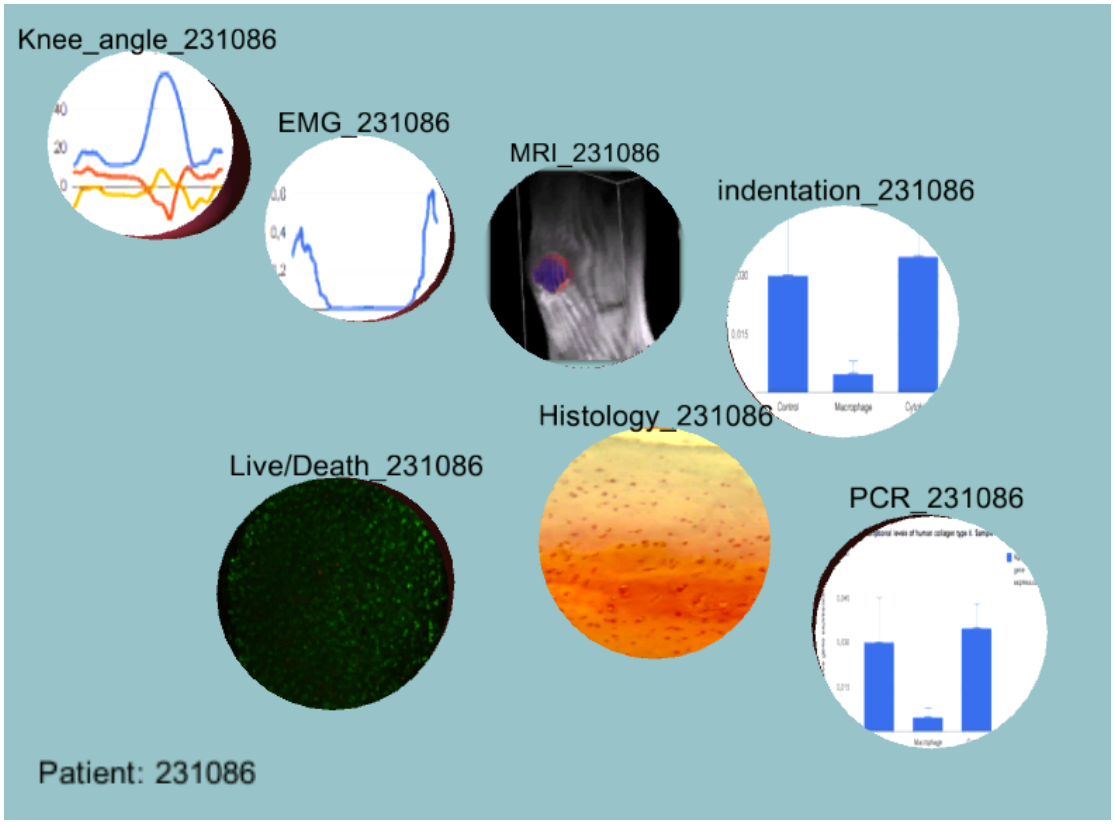
?x	?r1	?patient	?r2	?data	?r3	?y
Patient	*Is a*	*Patient 231086*	*concerns*	*Knee Angle 231086*	*Is a*	*Data*
Patient	*Is a*	*Patient 231086*	*concerns*	*EMG 231086*	*Is a*	*Data*
Patient	*Is a*	*Patient 231086*	*concerns*	*MRI 231086*	*Is a*	*Data*
Patient	*Is a*	*Patient 231086*	*concerns*	*Histology 231086*	*Is a*	*Data*

In the following we present queries (in English) and its “visual” results.

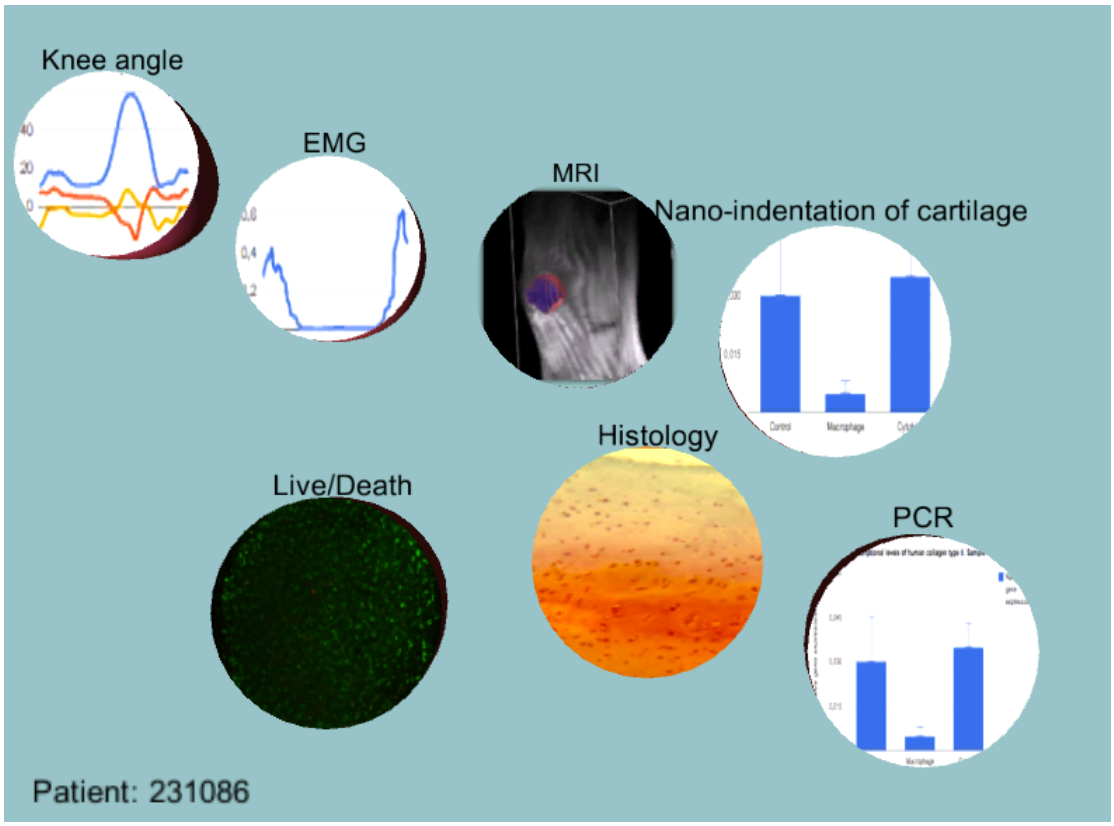
1: For a given patient which are all the data that she/he concerns?



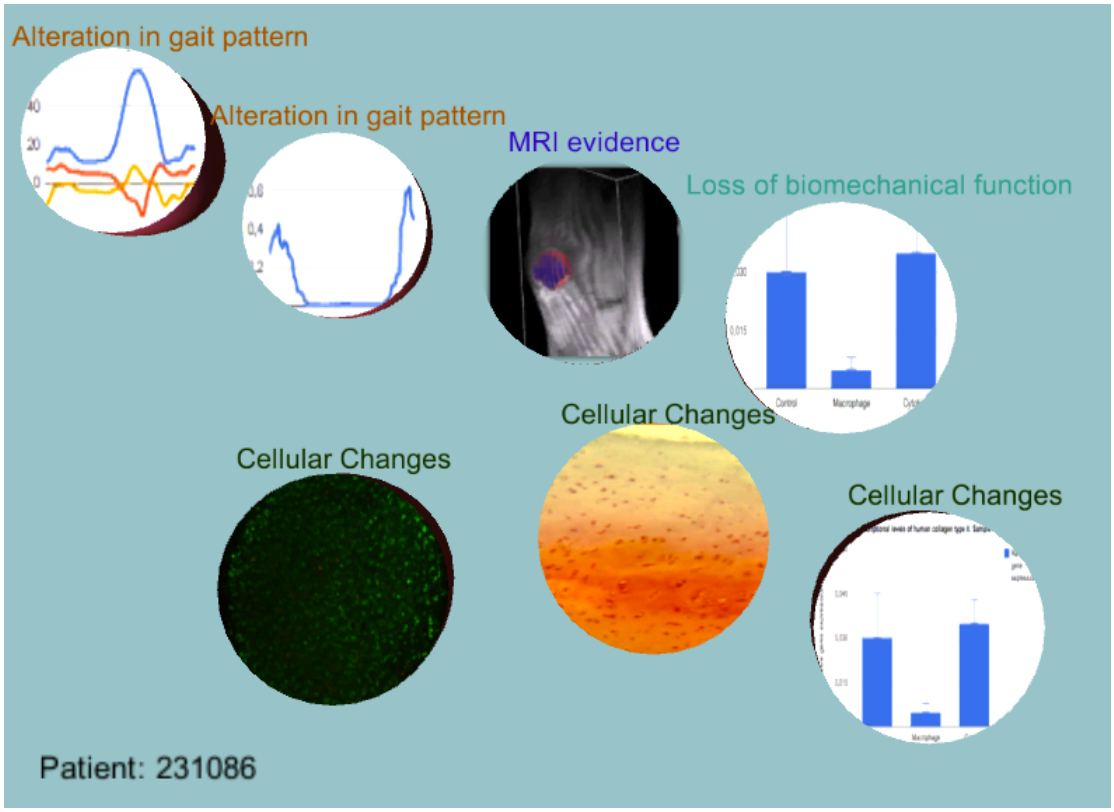
2: For the previously obtained data which are the visualization techniques with which they are visualized?



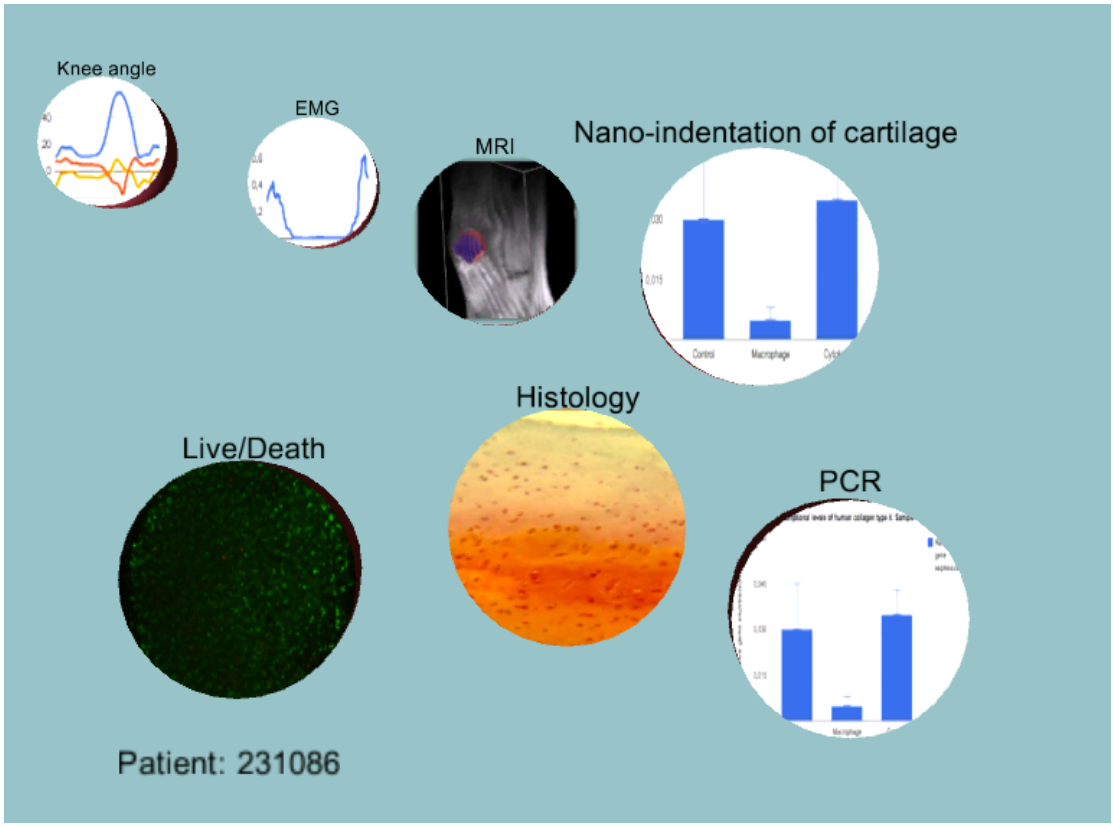
3: By which technique were the data in question obtained?



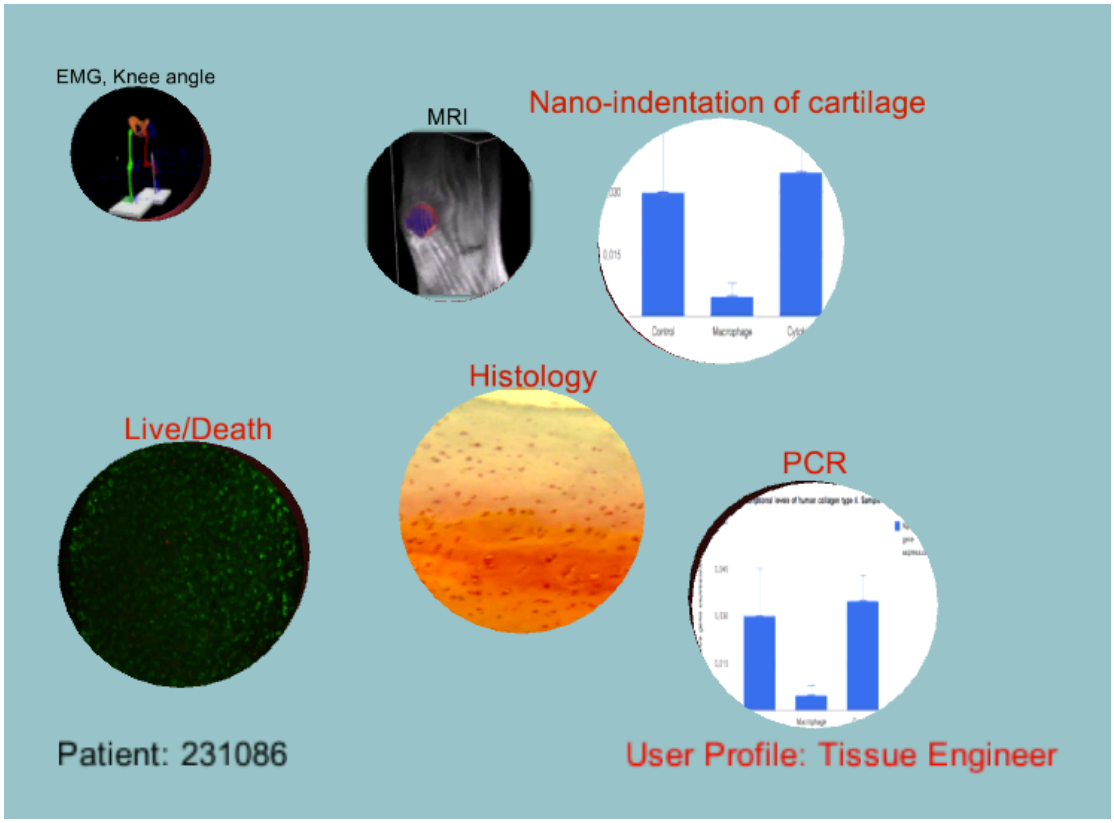
4: For the previously evaluated techniques, which are the sources of evidence that measured them. And for those sources of evidence which degradation process features did they evidence?



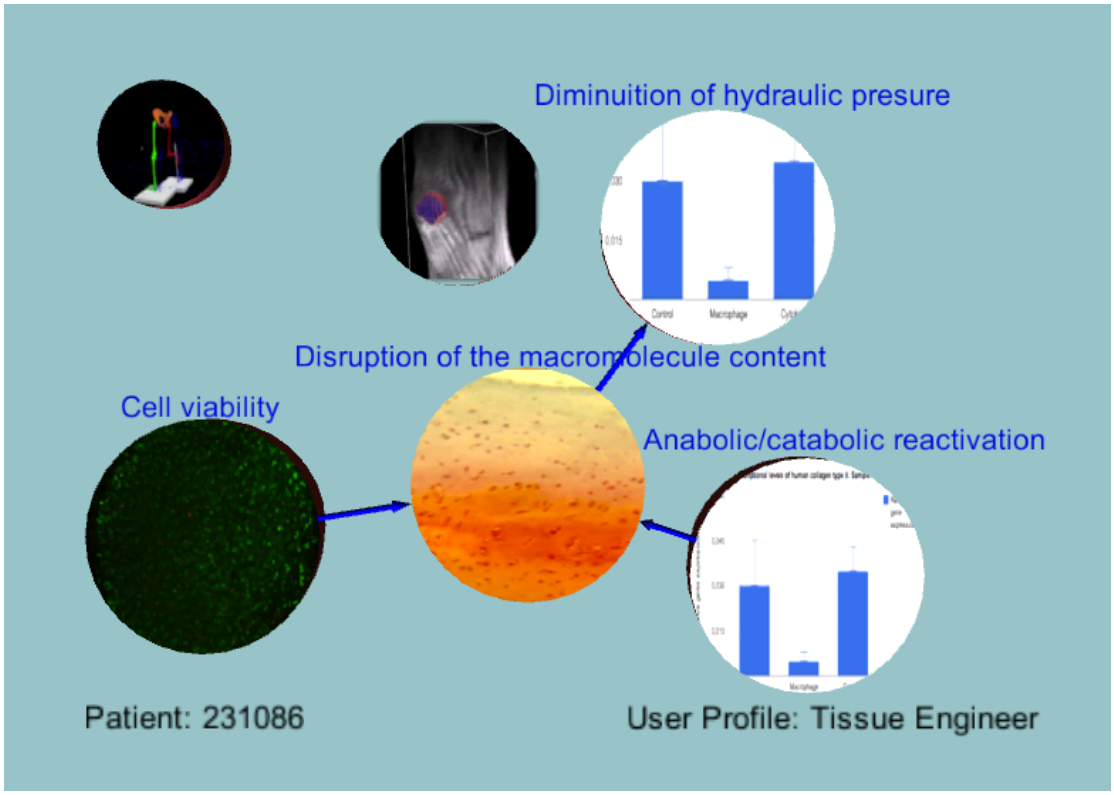
5: Which are the spatio-temporal scale for the obtained degradation process features?



6: Filter only those degradation process features that are of interest for a given user profile?



7: Causes between SoE?



8: Causes between DPF?