

1 Introduction

1.1	Prelude	1
1.2	Data Integration, Hypergraphs, and Type Theory	2
1.3	Philosophy and the Semantic Web	4
1.4	Navigating the Proliferation of Research Data	6

Part I: Biomedical Data Formats and Data Integration

2 Data Structures Associated with Biomedical Research

2.1	Introduction	1
2.2	Personalized Medicine in the Context of Covid-19	2
2.2.1	Precision Medicine as a Catalyst for Biomedical Data Sharing	3
2.2.2	Software Alignment for Covid Phylogeny Studies	4
2.2.3	Personalized Medicine and Immuno-Profilng	5
2.3	A Review of Certain Commonly-Used Biomedical Data Formats	6
2.3.1	DICOM (Digital Imaging and Communications in Medicine)	6
2.3.2	Next Generation Sequencing and other Genomics Formats	7
2.3.3	The Flow Cytometry Standard (FCS) File Format	9
2.3.4	Image Segmentation, Contours, and Regions of Interest	10
2.3.5	Common Data Models for Clinical Research	11

3 Data Mining and Predictive Analytics for Cancer and Covid-19

3.1	Introduction	1
3.2	Precision Medicine and Bioimaging	1
3.2.1	The Basic Synthesis Between Bioimaging and Precision Medicine	2
3.2.2	Multi-Application Networks in the Context of Scientific Research Data	3
3.3	Precision Medicine in Trial Design	4
3.3.1	Customizing Clinical Trial Management Software	5
3.3.1.1	Toward Fine-Grained Sociodemographic Models	6
3.3.1.2	Measuring Cognitive and Neurological Effects	6
3.3.1.3	Aggregating Trial Data via Graph Models	7
3.3.2	Representing Trial Data via Object Models	8
3.4	Text and Data Mining via CORD-19	8
3.4.1	Overview of CORD-19	9
3.4.2	Data Integration within CORD-19	10
3.4.3	Reviewing the CORD-19 Document Model	12

4 Modular Design, Image Biomarkers, and Radiomics

4.1	Introduction	1
4.2	Image Biomarkers (and Others) for Cardiac and Oncology Diagnostics	1
4.2.1	Image Registration and Radiomics for Cardiac Diagnosis	2
4.2.2	From Image-Annotations to Image Biomarkers	6
4.2.3	Tumor Histopathology and Simulation	9
4.3	Multi-Aspect Modular Design in a Heterogeneous Data Space	12
4.3.1	The Overlap Between Research and Clinical Data	13
4.3.2	The Problem of Software Ecosystem Fragmentation	15
4.4	Data-Integration via Multi-Aspect Modules	17
4.4.1	Research Dissemination and Incremental Replicability	18
4.4.2	Heterogeneous Health Data and Data Curation	20
4.4.3	Modularity and the Clinical/Research Overlap	22

Part II: Type Theory and Conceptual Spaces

5 Types' Internal Structure and "Non-Constructive" ("NC4") Type Theory

5.1	Introduction	1
5.1.1	Cocyclic Types, Precyclic and Endocyclic Tuples	1
5.1.2	Cocyclic Types for Hypernodes	1
5.1.3	Channelized Types and Channel Algebra	2
5.1.4	Constructors and Carrier States	3
5.1.5	Nonconstructive Type Theory	6
5.2	Types as Conceptual Structures	8
5.2.1	Dimensional Analysis and Axiations	9
5.3	Hypergraph Ontologies	11
5.3.1	Type Theoretic Foundations for Hypergraph-Based Data Sharing	14
5.3.2	Hypergraphs as a Meta-Model for Data Sharing	15

6 Using Code Models to Instantiate Data Models

6.1	Introduction	1
6.2	Syntagmatic Graphs and Pointcut Expression Semantics	2
6.2.1	Query-Evaluation Foundations for Syntagmatic Graphs	7
6.2.2	Use-Cases for Source-Code Graphs	8
6.3	Applying Pointcut Expressions for Data Modeling	9
6.3.1	Code Annotation with Units of Measurement	11
6.3.2	Documentation by Implementation	12
6.3.3	Annotation-Based Reflection and Procedural Binary Equivalence	13
6.3.4	Meta-Procedural, Procedural, and Sub-Procedural Syntagmatic Scales	16
6.3.5	Case Study: Annotation and Image Markup	16
6.4	Hypergraph Representations for Data-Persistence Bridge Code	17
6.4.1	Multipart Relations with Roles	20
6.4.2	Syntagmatic Graphs and Conceptual Spaces	22

Part III: Bioimage Annotations and Radiomics

- 7 Multi-Aspect Modules and Image Annotation
 - 7.1 Introduction 1
 - 7.1.1 Comments on Procedural and Database Aspectss 1
 - 7.1.2 Assessing the Proper Scope of an Image-Annotation Module 2
 - 7.2 Image Annotations: Core Data Models 4
 - 7.2.1 Magnitudes and Coordinates 5
 - 7.2.2 Annotations with Curved Geometries or Cross-References 8
 - 7.2.3 Annotations and Image Features 8
 - 7.2.4 Specifying Annotations' Roles and Origins 10
- 8 Image Annotation as a Multi-Aspect Case-Study
 - 8.1 Introduction 1
 - 8.1.1 Design Questions for Image-Annotation Modules 1
 - 8.1.2 Procedural Data Modeling (and the limitations of Ontologies) 3
 - 8.1.3 Different Aspects of Image-Annotation Data 5
 - 8.2 Annotations and Radiomics 7
 - 8.2.1 GUI Operations Involving Images and Image-Annotations 7
 - 8.2.2 Image Processing in the Context of Broader-Scale Workflows 9
 - 8.2.3 Data Profiles for Annotation and Image Markup 11
 - 8.2.4 Tradeoffs Between Data Models' Narrower and Wider Scope 13
- 9 Conceptual Spaces and Scientific Data Models
 - 9.1 Introduction 1
 - 9.2 Verb-Centric Grammars and Information-Delta Paths 2
 - 9.2.1 The Emergent Syntax/Semantics Interface 7
 - 9.3 Conceptual and Thematic Roles 7
 - 9.3.1 Disjoint Conceptual Spaces 9
 - 9.3.2 Conceptual Spaces and Scientific Data 14
 - 9.4 Delta Roles and Conceptual Space Markup Language 15
 - 9.4.1 Information Delta and Data Modeling 15
 - 9.4.2 The Artificiality of Data Semantics 17
 - 9.5 Conclusion: Toward a Scientific Data Semantics 18
 - 9.5.1 Research Data and Data Integration 19
 - 9.5.2 Toward a Procedural Conceptual-Space Semantics 20