



Towards decision support system for the agri-food sector using heterogeneous scientific data annotated with an ontology and Bayesian networks: a proof of concept applied to milk microfiltration

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Towards decision support system for the agri-food sector using heterogeneous scientific data annotated with an ontology and Bayesian networks: a proof of concept applied to milk microfiltration

Cédric Baudrit, **Patrice Buche**, Nadine Leconte, Christophe Fernandez, Maëllis Belna, Geneviève Gésan-Guiziou
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CATI DIISCICO



> Motivation and issues

Decision tasks based on the scientific literature in the agri-food sector (here milk microfiltration) because:

- Key role in the sector (here dairy sector)
- Need to improve prediction of unit operation performances and optimize plant design (here microfiltration)
- Existing models only available on restricted operating conditions

Issues

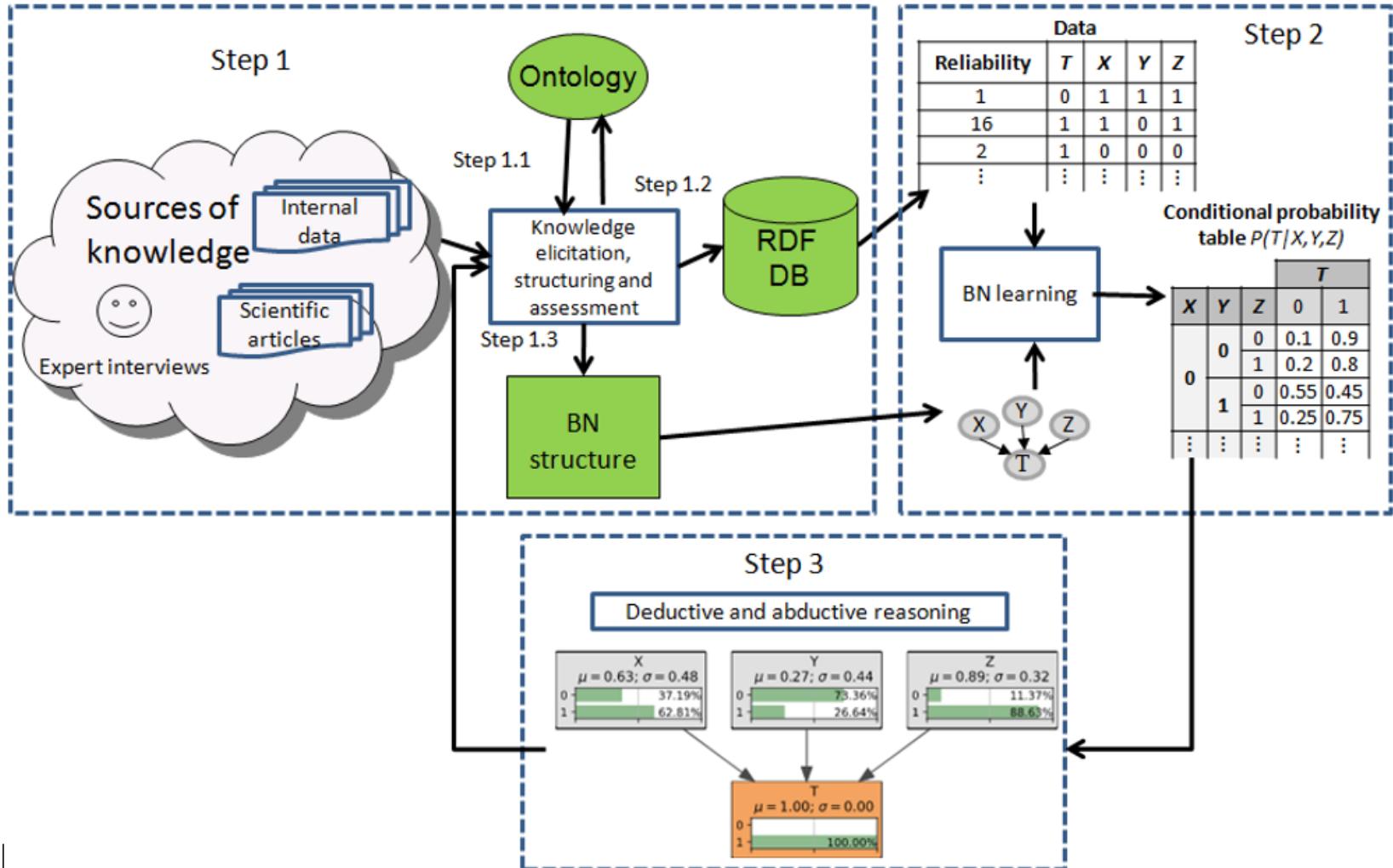
- Scientific data **heterogeneously** structured, available in textual format
- Data **uncertainty** due to processes involving biological material
- Data **reliability** due to the way experiments have been conducted

> Proposal

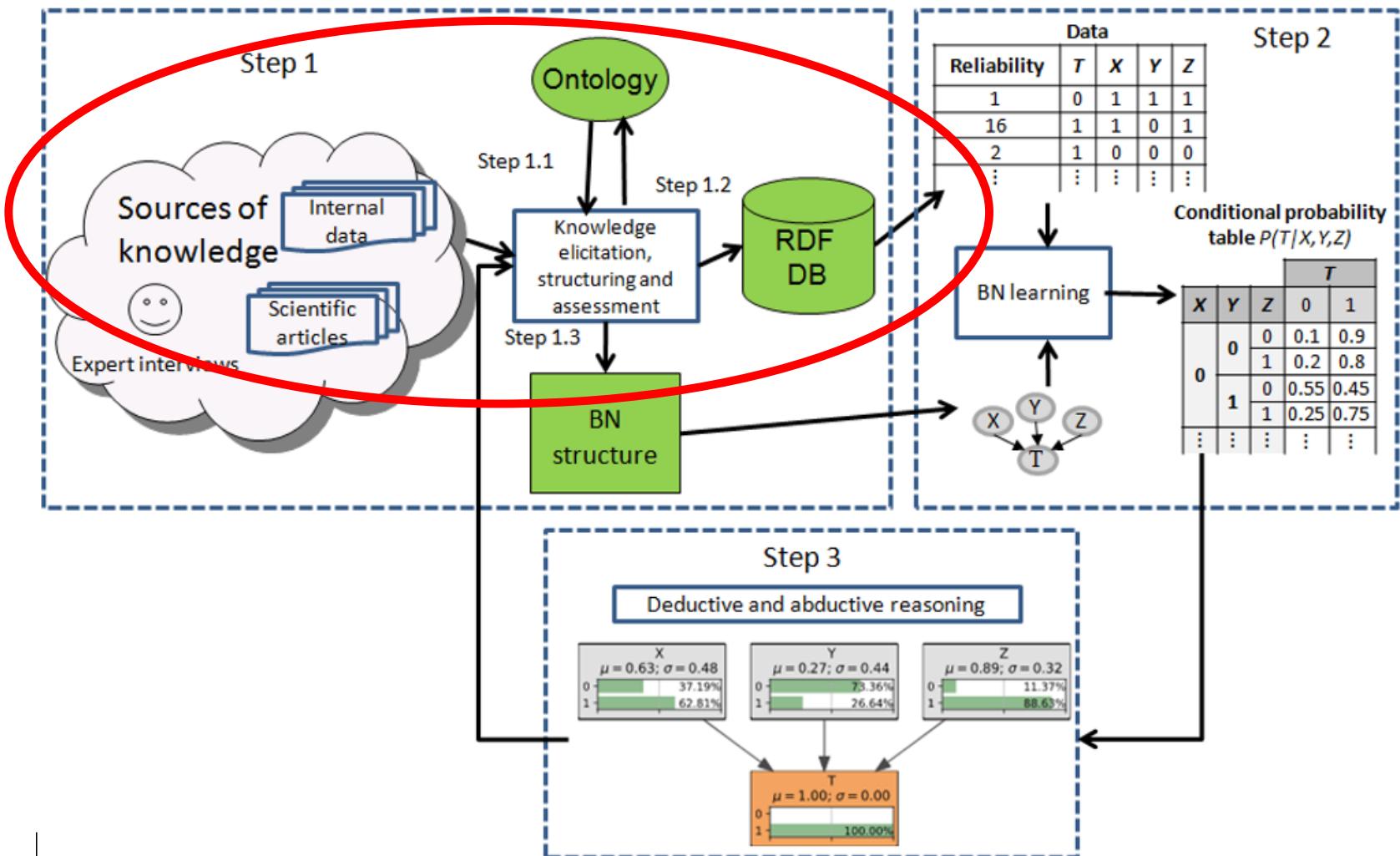
A **Decision Support System (DSS)** based on ontology and Bayesian networks which deals with the preceeding issues in order to:

- **structure and integrate** heterogeneous experimental data sources by using **ontologies**
- **provide open access** to annotated data
- **assess data source reliability**
- **learn Bayesian networks using uncertain data** taking into account data reliability

Decision Support System workflow



Decision Support System workflow



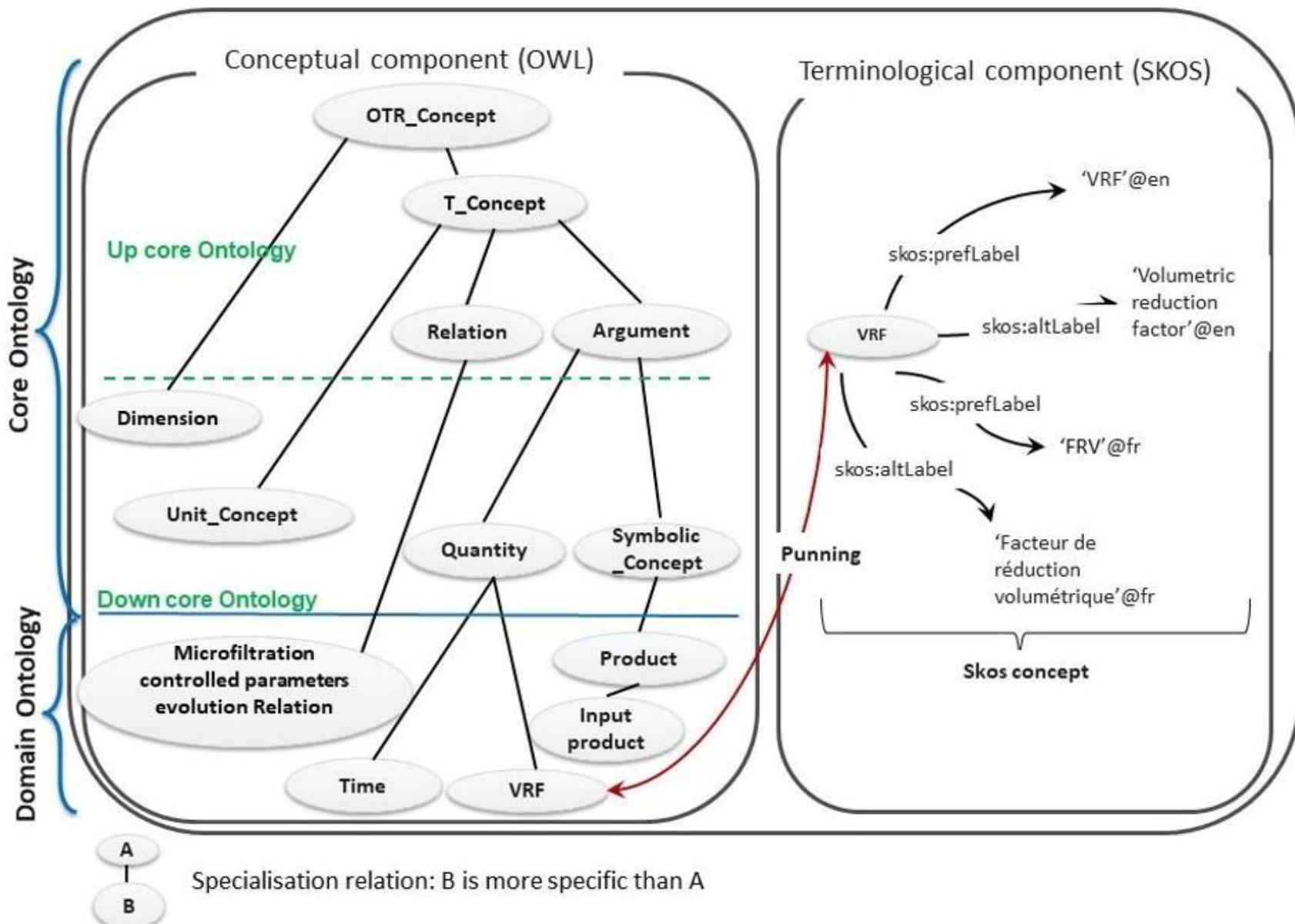
➤ Key ideas to integrate data

Representing knowledge using international standards to represent ontologies and data (semantic web languages as OWL/RDF)

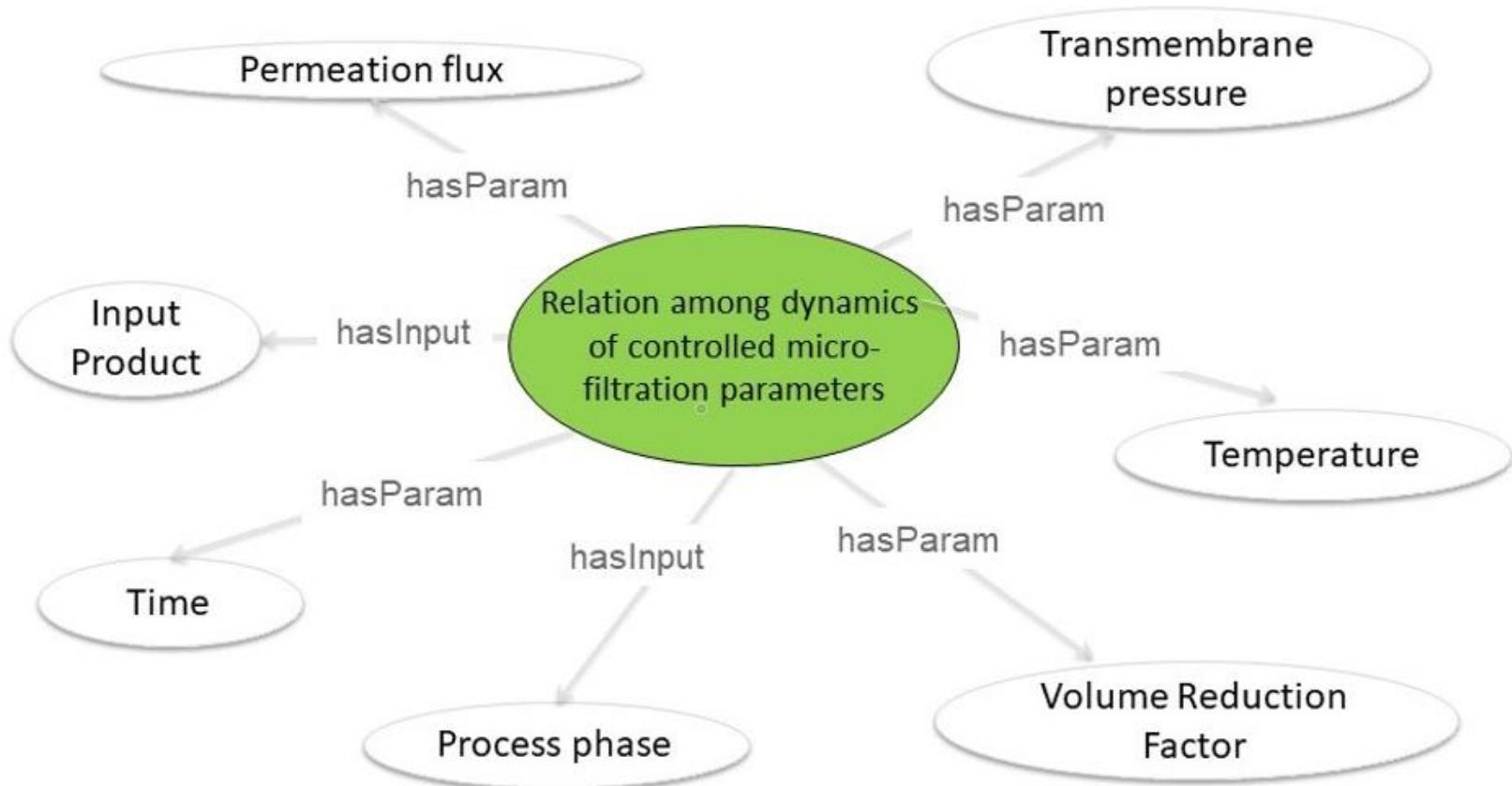
Using an ontological model to provide a reading grid for article annotation

Developing end-user oriented Web applications for ontology and data management based on semantic web languages

naRyQ Termino-Ontological Resource (TOR)



➤ OWL Relation concept to model unit operation involved in a bioprocess



<https://doi.org/10.15454/5MQMKG>
Milk Microfiltration v1.5

➤ Key ideas to integrate data

Representing knowledge using international standards to represent ontologies and data (semantic web languages as OWL/RDF)

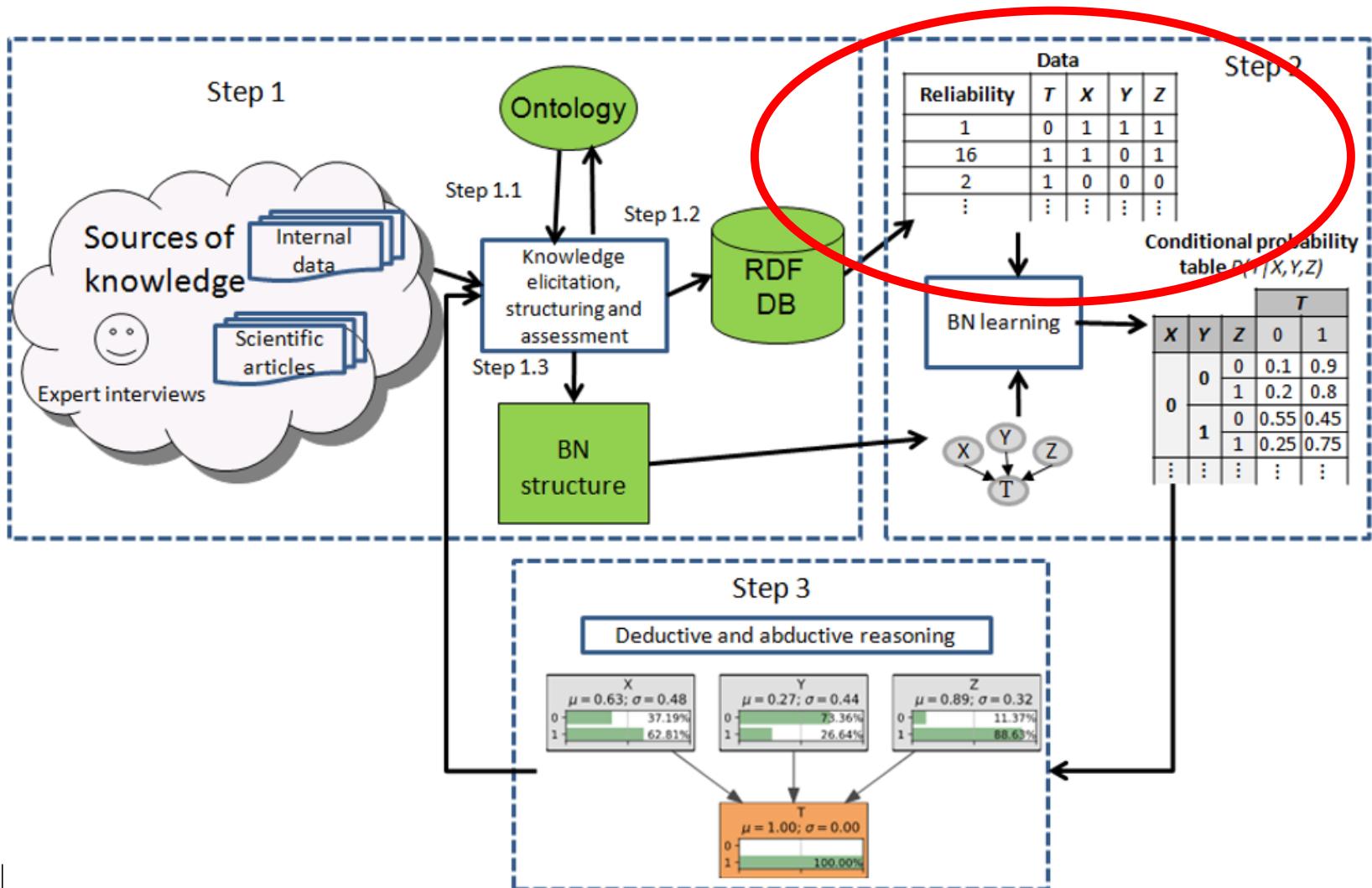
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➤ Relation concept instantiation in @Web import template CSV file

P	S	V	X	Y	AC	AD	AE	AM	AO	AP	AT	AW	AV	BE	BI	
1	Experience	Process step	Time_	Time_UNIT	Process phase	VRF_AVG	VRF_STD	VRF_UNIT	Temperature	Temp	TMP_MIN	TMP_UNIT	Jp_AVG	Jp_UNIT	Crossflow ve	Crossf
370	1	5	90	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	71,8369131	kPa	58,9	l.h-1.m-2	6,9	m.s-1
371	1	5	95	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	73,6860843	kPa	58,9	l.h-1.m-2	6,9	m.s-1
372	1	5	100	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	74,7661331	kPa	58,9	l.h-1.m-2	6,9	m.s-1
373	1	5	105	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	75,5516231	kPa	58,9	l.h-1.m-2	6,9	m.s-1
374	1	5	110	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	76,0425544	kPa	58,9	l.h-1.m-2	6,9	m.s-1
375	1	5	115	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	76,9262307	kPa	58,9	l.h-1.m-2	6,9	m.s-1
376	1	5	120	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	78,6935832	kPa	58,9	l.h-1.m-2	6,9	m.s-1
377	1	5	125	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	79,4790732	kPa	58,9	l.h-1.m-2	6,9	m.s-1
378	1	5	130	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	78,6935832	kPa	58,9	l.h-1.m-2	6,9	m.s-1
379	1	5	135	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	80,559122	kPa	58,9	l.h-1.m-2	6,9	m.s-1
380	1	5	140	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	81,4427983	kPa	58,9	l.h-1.m-2	6,9	m.s-1
381	1	5	145	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	83,1119646	kPa	58,9	l.h-1.m-2	6,9	m.s-1
382	1	5	150	min	Constant phase (constant VRF)	2,5	0,1	One	50,1	°C	82,8174058	kPa	58,9	l.h-1.m-2	6,9	m.s-1

Decision Support System workflow



➤ Key ideas to assess data source reliability

Defining meta data to evaluate (milk microfiltration) data source reliability

Using a model to merge metadata quotations

Developing end-user oriented Web applications

➤ Meta data quotations (milk microfiltration)

[Ontology](#)[Documents](#)[Query](#)Login : Password : [Sign in](#) / [Sign up](#)

- ▶ BIOPROCESS - V 95
- ▶ DURUM_WHEAT - V 44
- ▶ FOOD_COMPO - V 2
- ▶ FOOD_TEXTURE - V 56
- ▶ MICROFILTRATION - V 70
 - Download
 - Generate template import
 - View
 - Explore
 - View judgements on criteria
- ▶ TRANSMAT - V 107
- ▶ VALORCARN - V 19
- ▶ Unit Ontology

	unknown	not at all reliable	not at all or hardly	hardly reliable	hardly or average	average or reliable	reliable	reliable or very	very reliable
MF-Number of repetitions - Compositional analysis									
> 3 or more								++	
> 2							+		
> 1			-						
MF-Source Type									
> Book							+		
> Proceeding			-						
> Journal article superior IF quarter (in at least one area)									++
> Journal article second IF quarter (in at least one area)							+		
> Journal article third IF quarter (in at least one area)			-						
> Journal article inferior IF quarter (in at least one area)	--								
> Encyclopedia article					-+				
> Patent		-							
> Report		-							
> Thesis					-+				
> Science popularization article		-							

➤ Key ideas to assess data source reliability

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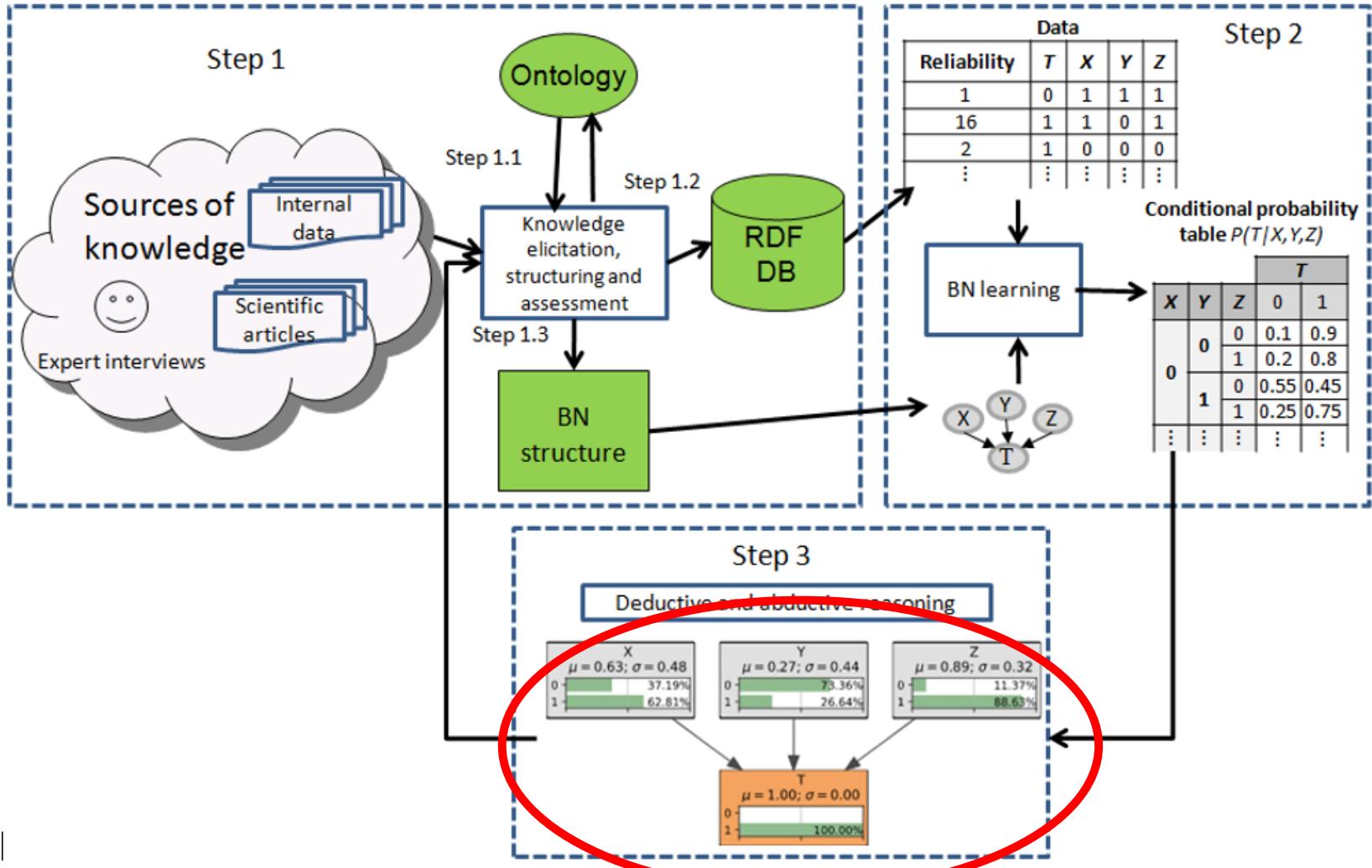
Developing end-user oriented Web applications

➤ Model with belief functions

- Inputs: metadata associated with the data source and expert quotations associated with metadata values
- Model with belief functions: merging quotations associated with metadata for a given data source (able to model ignorance, identify and manage conflicts)
- Output: estimated reliability $\left[\underline{E}_{d_i}, \overline{E}_{d_i}\right]$
- Usefulness: ranking of sources based on interval comparisons

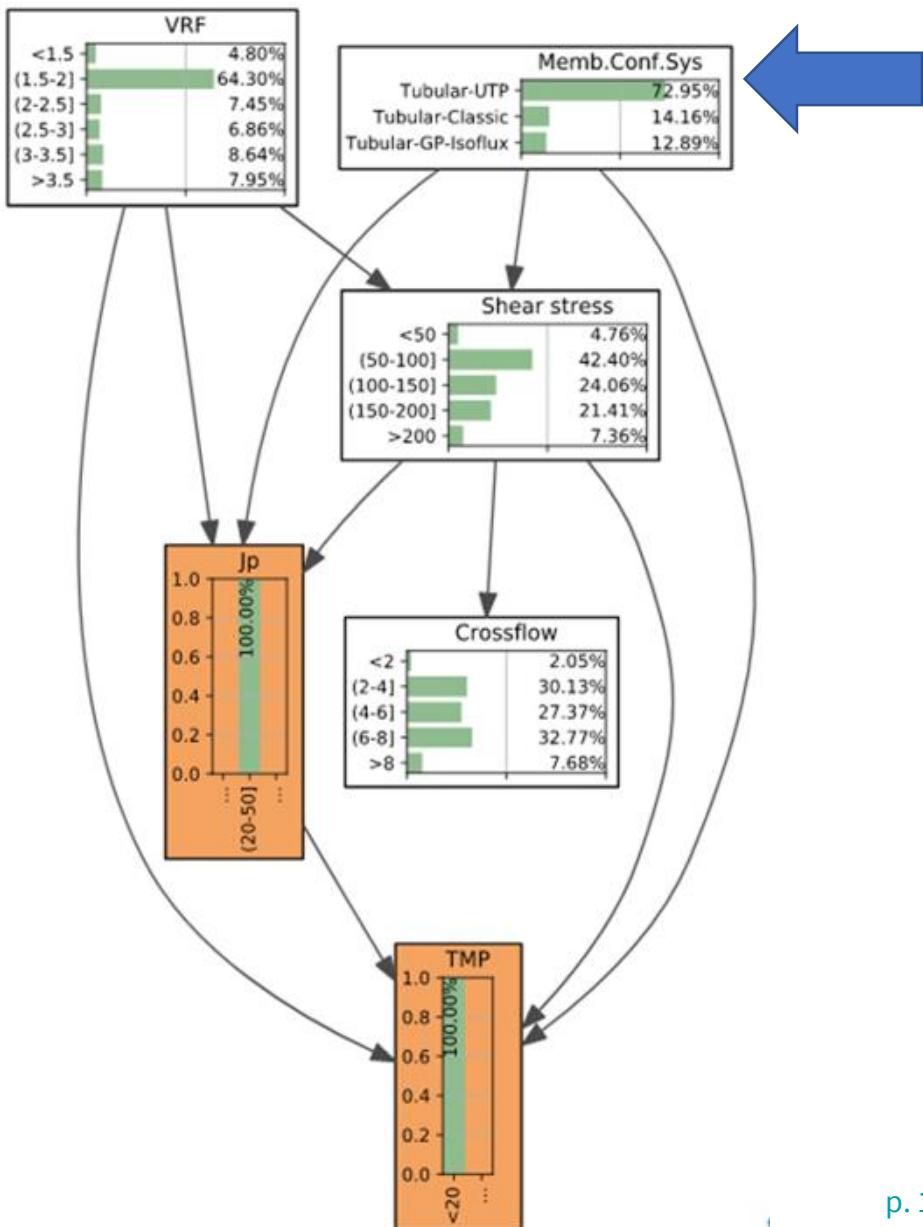
d_i	(#cit vs age)	repetitions	source type	$\left[\underline{E}_{d_i}, \overline{E}_{d_i}\right]$
d_1	-	No	Journal paper	[1.40,4.66]
d_2	(79,3)	Yes	Journal paper	[4.67,4.97]
d_3	-	No	Technical sheet	[1.05,1.40]

Decision Support System workflow



➤ Decision support using Bayesian network learned with data

Including data reliability in model's predictive accuracy based on leave-one-out cross-validation for **prediction of J_p** given shear stress, VRF constraints and the type of membrane used **increases the overall accuracy from 42% to 70%**



➤ Conclusion-perspectives

Conclusion

- Proposition of a generic ontological model (and associated tool) to guide manual annotation of scientific papers
- Reuse of annotated scientific data available in a SPARQL endpoint to learn a BN model for DSS
- Reliability assessment of data sources enhances model's predictive accuracy
- Preliminary version of a DSS dedicated to Milk Microfiltration taking into account large operating conditions

Perspectives

- Speeding up annotation using NLP guided by ontology (cf Martin's speech)
- impacts assessment of process parameters on milk quality parameters

➤ Questions ?

References

Buche, P., Dervaux, S., Leconte, N., Belna, M., Granger-Delacroix, M., Garnier-Lambrouin, F., Gesan-Guiziou, G. (2021). Milk microfiltration process dataset annotated from a collection of scientific papers. Data in Brief, 36 doi:10.1016/j.dib.2021.107063

Baudrit Cédric, Buche, P., Leconte, N., Belna, M., Fernandez C., Gesan-Guiziou, G. (2021). Decision support tool for the agri-food sector using data annotated by ontology and Bayesian network: a proof of concept applied to milk microfiltration (submitted to IJAEIS)

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➤ Key ideas to integrate data

Representing knowledge using international standards to represent ontologies and data (semantic web languages as OWL/RDF)

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➤ Relation concept instantiation in @Web web app

@Web
Ontology
Documents
Query

Login :
 Password :

Sign in / Sign up

Isotherm

MF Milk HT-MF

- A Novel Rig Design
- A process efficiency
- Critical stability con
- Crossflow microfiltr
- Depletion of Whey
- Effect of annatto ac
- Effect of ceramic m
- Effect of ceramic m
- Effect of microfiltrat
- Effect of soluble ca
- Efficiency of serum
- Experimental evalu
- Flat ceramic memb
- Fractionation by mi
- Impact of colloidal i
- Influence of casein
 - List of samples
 - Microfiltration co
 - Microfiltration pro**
 - Sample character
- Ionic strength depe
- Limiting Flux and C
- Manufacture of Mo:
- Microfiltration (0.1u
- Microfiltration of mil
- Microfiltration of mil

Microfiltration process description

n°	Treatment	Input product	Experience number Unit : 1	Process step number Unit : 1	Treatment duration Unit : s	Temperature Unit : oC	Rotation speed	Membrane Reference	Manufacturer	Membrane material	Membrane Configuration
1	Skimming	Milk	Experience number 1.000e+00	Process step number 1.000e+00		Temperature 4.000e+00	Rotation speed				
2	Heat Treatment Pasteurization	Intermediate product	Experience number 1.000e+00	Process step number 2.000e+00	Treatment duration 1.600e+01	Temperature 7.200e+01					
3	Storage	Intermediate product	Experience number 1.000e+00	Process step number 3.000e+00							
4	Temperature Holding	Intermediate product	Experience number 1.000e+00	Process step number 4.000e+00		Temperature 5.000e+01					
5	Microfiltration Separation Micelles-Seric protein	Product input separation step	Experience number 1.000e+00	Process step number 5.000e+00	Treatment duration 1.200e+02			FR FG7838-OS0x-S	Parker-Hannifin	PVDF	Spiral

➤ Key ideas to assess data source reliability

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➤ Data source reliability assessment

Document's general information

Document's name :
Optimization of protein fractionation by skim milk microfiltration: Choice of ceramic membrane pore size and filtration temperature

Associate topic : MFMilk HT-MF

Associate ontology : MICROFILTRATION

Accepted Tables : 5

Rejected Tables : 0

Untreated Tables : 0

Authors :
Jorgensen, C. E., Abrahamsen, R. K., Rukke, E.-O., Johansen, A.-G., Schüller, R. B., Skeie, S. B.

Journal : Journal of Dairy Science

Year : 2016

Volume : 99

Issue : 2016P 6164-6179.

Identifier : <http://doi.org/10.3168/jds.2016-11090>

Document criteria values

Criterion MF-Number of replicates - Compositional analysis

MF-Number of replicates - Compositional analysis : 3 or more

Criterion MF-Source Type

MF-Source Type : Journal article first IF quartile (in at least one area)

Criterion MF-Assay type

MF-Assay type : As a function of time (<2h)

Criterion MF-Number of replicates - Microfiltration essays

MF-Number of replicates- Microfiltration essays : 2 or more

Criterion MF-Operating mode

MF-Operating mode : Batch (UTP/GP)

Criterion MF-Number of automatic parameter controls during MF

MF-Number of automatic parameter controls during MF : 4 or more

Criterion MF-Initial product state

MF-Initial product state : Liquid milk

Criterion MF-Protein analysis method

MF-Protein analysis method : Kjeldahl

Reliability model



Reliability assessment document information

Reliability results

Low expectation : 4.7 ; High expectation : 4.99

Known criteria values rate : 100.0 %

Last assessment date (yyyy-mm-dd) : 2020-03-09