Il process mining in healthcare

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Work process

A set of logically related tasks performed to achieve a defined business outcome for a particular customer or market.

output that is of value to the customer.

environment. These activities jointly realize a business goal.

- - (Davenport, 1992)
- A collection of activities that take one or more kinds of input and create an
 - (Hammer & Champy, 1993)
 - set of activities performed in coordination in an organizational and technical
 - (Weske, 2011)









medical guidelines clinical pathways treatment protocols

fined business

(Davenport, 1992)

ut and create an

mer & Champy, 1993)

an organizational and technical

(Weske, 2011)







How to create intelligent information systems to support (healthcare) professionals in process enactment and decision making?







Why process models?

Documentation

Design-time support

- What-if analysis, teaching
- Simulation
- Verification

Runtime support: enactment and orchestration



Why process models?

Documentation

Design-time support

- What-if analysis, teaching
- Simulation
- Verification

Runtime support: enactment and decision making

Only useful if they accurately represent reality!



"modelling" vs "doing"



"modelling" vs "doing"



Problem #1 Flexibility



Problem #2 The two realities within organisations



managers & analysts

- definition of business goals
- definition of operational processes
- strategic decision making
- resource planning

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. . .

produce models





- day-by-day realization of goals
- execution of operational processes
- runtime decision making
- resource allocation

. . .

generate data











Event log

	-	_			
Case id	Activity	Timestamp	Transaction type	Resource	•••
•••	•••	•••	•••		
253	ER Triage	04–13-2021	complete	Nurse 1	• • •
		11:33:50			
255	Release A	04–13-2021	complete	Physician	• • •
		11:35:05		02	
259	Lactic Acid	04–13-2021	complete	Nurse 4	• • •
		11:38:55			
254	Leucocytes	04–13-2021	complete	Nurse 5	• • •
		11:41:23			
256	Lactic Acid	04–13-2021	complete	Nurse 4	• • •
		11:52:35			
257	ER Triage	04–13-2021	complete	Nurse 7	• • •
		11:53:16			
258	ER	04–13-2021	complete	Nurse 8	• • •
	Registration	11:54:47			
253	Admission	04–13-2021	complete	Physician	•••
	NC	11:55:26		02	
259	Admission IC	04–13-2021	complete	Physician	• • •
		11:58:30		03	
260	CRP	04–13-2021	complete	Nurse 07	• • •
		12:01:12			
261	Release B	04–13-2021	complete	Physician	•••
		12:02:00		03	
253	IV Liquid	04–13-2021	complete	Nurse 2	• • •

https://ceur-ws.org/Vol-1859/bpmds-08-pap

<u>e</u>	r.	p	<u>d</u>	f
		_		

Event log subject/insta

ance	what	W
	_	_
Case id	Activity	Tim
253	ER Triage	04–1 11:3
255	Release A	04–1 11:3
259	Lactic Acid	04–1 11:3
254	Leucocytes	04–1 11:4
256	Lactic Acid	04–1 11:5
257	ER Triage	04–1 11:5
258	ER Registration	04–1 11·5
253	Admission	04–1 11.5
259	Admission IC	11.5 04–1
260	CRP	11:5 04–1

 Image: Critical and the sector
 12:0

 Release B
 04–1

 12:0
 12:0

 IV Liquid
 04–1

261

253

https://ceur-ws.org/Vol-1859/bpmds-08-pap



<u>e</u>	r.	p	<u>d</u>	f
		_		

Event log



https://ceur-ws.org/Vol-1859/bpmds-08-pap

<u>e</u>	r.	p	<u>d</u>	f
		_		





Process mining: "data science in action"

Wil van der Aalst

Process Mining

Data Science in Action Second Edition

Wil M. P. van der Aalst Josep Carmona (Eds.)

448

NBIP

Deringer

Process Mining Handbook







A manifesto is a "public declaration of principles and intentions" by a group of people. This manifesto is written by members and supporters of the IEEE Task Force on Process Mining. The goal of this task force is to promote the research, development, education, implementation, evolution, and understanding of process mining.

Process mining is a relatively young research discipline that sits between computational intelligence and data mining on the one hand, and process modeling and analysis on the other hand. The idea of process mining is to discover, monitor and improve real processes (i.e., not assumed processes) by extracting knowledge from event logs readily available in today's (information) systems. Process mining includes (automated) process discover (i.e., extracting process models from an event log), conformance checking (i.e., monitoring deviations by comparing model and log), social network/ organizational mining, automated construction of simulation models

model extension, model repair, case prediction, and history-based recommendations.

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Process mining techniques are able to extract knowledge from event logs commonly available in today's information systems. These techniques provide new means to discover, monitor, and improve processes in a variety of application omains. There are two main drivers for the growing interest in process mining. On the one hand, more and more events are being recorded, thus, providing detailed information about the history of processes. On the other hand, there is a need to improve and support business processes in competitive and rapidly changing environments. This manifesto is created by the IEEE Task Force on Process Mining and aims to promote the topic of process mining. Moreover, by defining a set of guiding principles and listing important challenges, this manifesto hopes to serve as a guide for software developers, scientists, consultants, business managers, and end-users. The goal is to increase the maturity of process mining as a new tool to improve the (re)design, control, and support of operational business processes.





https://www.tf-pm.org

Process mining in healthcare

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Original Research

Process mining for healthcare: Characteristics and challenges

Jorge Munoz-Gama^{a,*}, Niels Martin^{b,c,*}, Carlos Fernandez-Llatas^{d,g,*}, Owen A. Johnson^{e,*}, Marcos Sepúlveda^{a,*}, Emmanuel Helm^{f,*}, Victor Galvez-Yanjari^{a,*}, Eric Rojas^a, Antonio Martinez-Millana^d, Davide Aloini^k, Ilaria Angela Amantea^{1,q,r}, Robert Andrews^{ab}, Michael Arias^z, Iris Beerepoot^o, Elisabetta Benevento^k, Andrea Burattin^{ai}, Daniel Capurro^j, Josep Carmona^s, Marco Comuzzi^w, Benjamin Dalmas^{aj, ak}, Rene de la Fuente^a, Chiara Di Francescomarino^h, Claudio Di Ciccioⁱ, Roberto Gatta^{ad, ae}, Chiara Ghidini^h, Fernanda Gonzalez-Lopez^a, Gema Ibanez-Sanchez^d, Hilda B. Klasky^p, Angelina Prima Kurniati^{al}, Xixi Lu^o, Felix Mannhardt^m, Ronny Mans^{af}, Mar Marcos^v, Renata Medeiros de Carvalho^m, Marco Pegoraro^x, Simon K. Poon^{ag}, Luise Pufahl^u, Hajo A. Reijers^{m, o}, Simon Remy^y, Stefanie Rinderle-Ma^{ah}, Lucia Sacchi^t, Fernando Seoane^{g, am, an}, Minseok Song^{aa}, Alessandro Stefanini^k, Emilio Sulis¹, Arthur H. M. ter Hofstede^{ab}, Pieter J. Toussaint^{ac}, Vicente Traver^d, Zoe Valero-Ramon^d, Inge van de Weerd^o, Wil M.P. van der Aalst^x, Rob Vanwersch^m, Mathias Weske^y, Moe Thandar Wynn^{ab}, Francesca Zerbatoⁿ



SPRINGER BRIEFS IN BUSINESS PROCESS MANAGEMENT

Ronny S. Mans Wil M.P. van der Aalst Rob J.B. Vanwersch

Process Mining in Healthcare Evaluating and Exploiting Operational Healthcare Processes





Process

Play in



Play out

Replay





event log

Case id	Activity	Timestamp	Transaction type	Resource	
••••					
253	ER Triage	04–13-2021 11:33:50	complete	Nurse 1	
255	Release A	04–13-2021 11:35:05	complete	Physician 02	
259	Lactic Acid	04–13-2021 11:38:55	complete	Nurse 4	
254	Leucocytes	04–13-2021 11:41:23	complete	Nurse 5	•••
256	Lactic Acid	04–13-2021 11:52:35	complete	Nurse 4	•••
257	ER Triage	04–13-2021 11:53:16	complete	Nurse 7	•••
258	ER Registration	04–13-2021 11:54:47	complete	Nurse 8	•••
253	Admission NC	04–13-2021 11:55:26	complete	Physician 02	••••
259	Admission IC	04–13-2021 11:58:30	complete	Physician 03	





Replay: enhancement Frequencies

Case id	Activity	Timestamp	Transaction type	Resource	
				•••	
253	ER Triage	04–13-2021	complete	Nurse 1	••••
		11:33:50			
255	Release A	04–13-2021	complete	Physician	•••
		11:35:05		02	
259	Lactic Acid	04–13-2021	complete	Nurse 4	•••
		11:38:55			
254	Leucocytes	04–13-2021	complete	Nurse 5	
		11:41:23			
256	Lactic Acid	04–13-2021	complete	Nurse 4	
		11:52:35			
257	ER Triage	04–13-2021	complete	Nurse 7	
		11:53:16			
258	ER	04–13-2021	complete	Nurse 8	
	Registration	11:54:47			
253	Admission	04–13-2021	complete	Physician	
	NC	11:55:26		02	
259	Admission IC	04–13-2021	complete	Physician	
		11:58:30	-	03	
260	CRP	04–13-2021	complete	Nurse 07	
		12:01:12	-		
261	Release B	04–13-2021	complete	Physician	
		12:02:00	*	03	
253	IV Liquid	04–13-2021	complete	Nurse 2	
	-	12:05:33	*		
•••					







Replay: enhancement Frequencies

Case id	Activity	Timestamp	Transaction type	Resource	
253	ER Triage	04–13-2021	complete	Nurse 1	
		11:33:50			
255	Release A	04–13-2021	complete	Physician	
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256	Lactic Acid	04–13-2021	complete	Nurse 4	
		11:52:35			
257	ER Triage	04–13-2021	complete	Nurse 7	•••
		11:53:16			
258	ER	04–13-2021	complete	Nurse 8	•••
	Registration	11:54:47			
253	Admission	04–13-2021	complete	Physician	
	NC	11:55:26		02	
259	Admission IC	04–13-2021	complete	Physician	
		11:58:30	-	03	
260	CRP	04–13-2021	complete	Nurse 07	
		12:01:12	-		
261	Release B	04–13-2021	complete	Physician	
		12:02:00	-	03	
253	IV Liquid	04–13-2021	complete	Nurse 2	
	-	12:05:33	•		
•••					



Replay: enhancement Delays

Case id	Activity	Timestamp	Transaction type	Resource	
••••					
253	ER Triage	04–13-2021	complete	Nurse 1	•••
		11:33:50			
255	Release A	04–13-2021	complete	Physician	•••
		11:35:05		02	
259	Lactic Acid	04–13-2021	complete	Nurse 4	•••
		11:38:55			
254	Leucocytes	04–13-2021	complete	Nurse 5	
		11:41:23			
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		11:52:35			
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		11:53:16			
258	ER	04–13-2021	complete	Nurse 8	
	Registration	11:54:47			
253	Admission	04–13-2021	complete	Physician	
	NC	11:55:26		02	
259	Admission IC	04–13-2021	complete	Physician	
		11:58:30		03	
260	CRP	04–13-2021	complete	Nurse 07	
		12:01:12			
261	Release B	04–13-2021	complete	Physician	
		12:02:00		03	
253	IV Liquid	04–13-2021	complete	Nurse 2	
		12:05:33			







Typical questions in PM for healthcare [Mans et al, ProHealth/KR4HC 2012]

- exceptional ones?
- 2. How do **clinical pathways** followed by different groups of patients compare to each other?
- 3. Are executions conforming with internal/external clinical guidelines?
- 4. What are the main **bottlenecks**?

1. What are the most frequent paths? And the outlier/

Monitoring multiple process components in healthcare [_,ProHealth/KR4HC 2011][___,CAiSE 2022]

- Starting point: non-trivial interaction between clinical guidelines and background medical knowledge multiple clinical guidelines executed concurrently

Idea

- Instead of dealing with this interaction explicitly... Monitor what happens, and immediately report deviations,
- violations,
- Give feedback on "best possible outcome"

Monitoring multiple process components in healthcare ,ProHealth/KR4HC 2011][___,CAiSE 2022]



- Monitor what happens, and immediately report deviations, violations,
- Give feedback on "best possible outcome"

Conclusions

High potential for healthcare applications

its distinguishing features [Munoz-Gama et al, JBI 2022]:

- 1. substantial variability
- 2. infrequent behaviour
- 3. documented guidelines/protocols 8. need for white-box approaches
- 4. context is key
- 5. data at multiple abstraction levels 10.continuous evolution of the field

Process mining: fact-based insights on the actual execution of processes

Need for specialised process mining techniques for healthcare dealing with

- 6. multidisciplinary teams
- 7. focus on the **patient**
- 9. presence of sensitive, low-quality data

