



UtilityAnalytics®

October 18-20, 2022
San Diego, CA

WEEK

UtilityAnalyticsWeek.com

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San Diego, CA

Maintenance decision support tool with a smart recommender system

Elkin Cantor, Asset Manager, ISA INTERCOLOMBIA S.A. E.S.P

@weareUAI | #UAWWeek #UtilityAnalytics

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isa
INTERCOLOMBIA

Elkin Cantor

From 2011 to 2014, Elkin Cantor worked at INTERCONEXIÓN ELÉCTRICA S.A (ISA) in Colombia, and he now works at ISA INTERCOLOMBIA S.A. as an asset manager in the maintenance department. He has led several projects involving power transformer maintenance strategy, failure analysis and condition assessments for high voltage substations. Elkin has a bachelor's degree in electrical engineering and a Master's degree in the same field. Currently, he is studying for a Master's degree in data science.



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Electric Power Transmission

99,99%

Reliability



Presence

Business Units

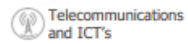


Energy

- Energy Transmission
- Real-Time System Management (RTM)
- New Businesses



Roads



Telecommunications and ICT's

Sustainability

Corporate Governance

Stakeholders

Financial Information

Strategy

In operation
47.358 Km
and 92.720 MVA *

Under construction
6.529 Km
and 15.603 MVA



It's the equivalent doing a lap and a half of planet Earth

USD 9.6 billion
Investment target
by 2030

Market share
Revenues



- Average time for concessions **25 years**
- In Colombia and Chile, **concessions are perpetual**



Figures as of march 2021 7

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Artificial Intelligence Opportunities In Business

There are three key use cases for AI in business, which can overlap to some degree, but help to segment the opportunities.

For Example:

1. Change the way you understand and interact with customers.
2. Offer more intelligent products and services
3. Improve and automate business processes

[1]. Artificial Intelligence in Practice: How 50 Successful Companies Used AI and Machine Learning to Solve Problems Book by Bernard Marr

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What is not a recommender system

A recommender system is NOT a system that “recommends” arbitrary values.

For Example:

- A system that “recommends” prices for a house you’re selling is NOT a recommender system.
- A system that “recommends” whether a transaction is fraudulent is NOT a recommender system

These are general machine learning problems, where you’d apply techniques such as Regression, deep learning or other techniques.

[2]. Building Recommender Systems with Machine Learning and AI: Help people discover new products and content with deep learning, neural networks, and machine learning recommendations. Book by Frank Kane

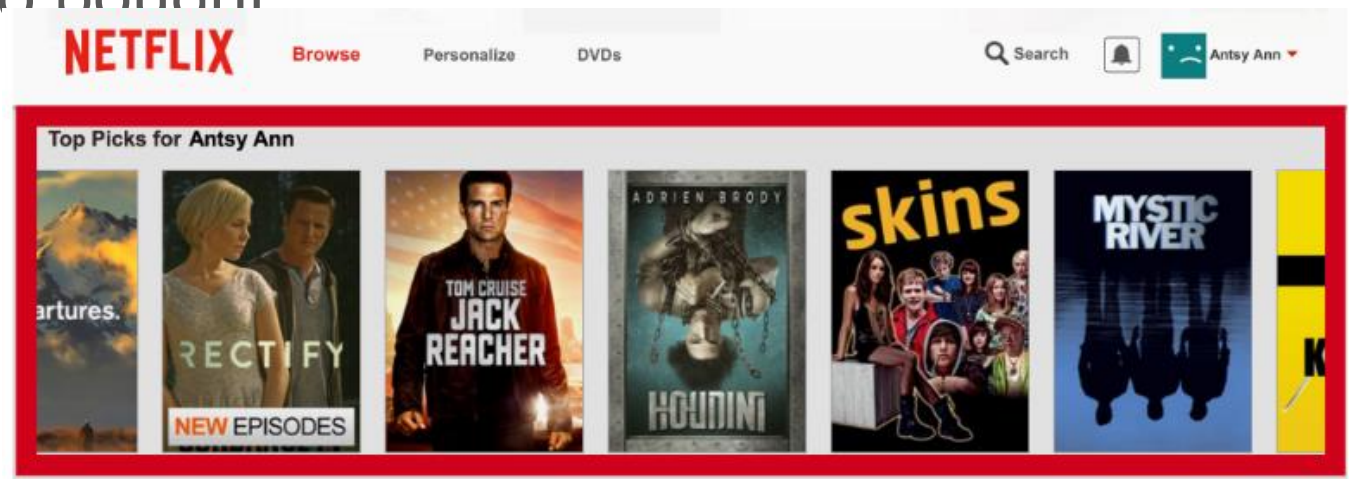
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What is a recommender system

A system that predicts ratings or preferences a user might give to an item. Often these are sorted and presented as “top-N” recommendations

- Netflix’s home page
- Google search
- Amazon’s “people who bought also bought ”
- Online radio stations
- Youtube



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Why not think in a recomender system for maintenance ?

When people apply creativity to the things around them, innovation occurs.

Replicate – The ability to place existing things in a new context. Some of the best creative breakthroughs come from the simple act of placing a preexisting thing, idea or practice in a new context.

Associate – The ability to use analogous thinking to problem-solve. Analogies make the novel feel more familiar or, alternately, encourage people to think of familiar things in new ways.

[3]. The Creative Mindset Mastering the Six Skills That Empower Innovation . Book by Staney DeGraff and Jeff DeGraff

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Replication and Association for a Maintenance Recommender system

E-Commerce and Contend Context

- More sales/consumption guiding the user based on their needs.
- Agility in the purchase/consumption process

Asset and Maintenance context

- Proper maintenance based on its failure mode.
- Agility reducing response times when you have an equipment with a failure

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What is the process that we are going to impact?



Maintenance inspection report
Preventive and corrective maintenance
Monitoring systems



ERP
Enterprise
Resource
Planning



Rule Conditions



Health index
of the assets

Automatic Evaluation



**Maintenance
Actions to take
care of assets**

Recommender System
support the making-decision
process

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Dataset for the recommender system?

Historical Health Index, since 2010

Visualizar documento de medida: Datos generales

Documentos de medición Último docum.med... Último docum.medida

Documento med. 11195869

Punto de medida 625857 Tipo Evaluación

Posición medida AUTOTRAFO TOTAL Calificación del equipo

Equipo 111103

Denominación Autotrafo Monofásico 500/220 kV-RV

Datos de documento

Hora medición 19.07.2013 / 16:19:51 Docum. tras medida

Característica CALIFICACION_EQUIPO Calificación del equipo

Unidad caract. UNI UNIDADES

Valor medido 3,00

Valor teórico +

Código valorac.

Texto //6-HUM=DELTA/T_M/T_TRF//6-HUM_PAP=DELT... Txt.explicativo

Info adicional

Lectura ISA3121

Estado trat.

Diffents levels of conditions

- 1 } Bad Condition
- 2 }
- 3 } Close follow-up
- 5 } Good Condition, no need maintenace actions

Main Algorithm	Main Group	Failure mode	Failure mode code	Example
Dissolved Gas Analysis	DGA	Thermal failure in oil	T.ACE	2-DGA=T.PAP/DP//
		Themal failure in paper	T.PAP	
		Partial Discharge	DP	
		Electric Arc	ARC	

Dataset for the recommender system

Historical Maintenance Actions for each failure mode Since 2010

Example for a Failure mode in mechanical protection in power transformer

PRO-M

← Code in the health index



Id Equipment	Id Maintenance	Description
112135	193845	Wiring insulation measurement
123183	193844	Check Buchholz relay
111566	193854	Calibrate winding temperature indicator
111569	193862	Change pressure relief valve
111966	193859	Install seal relay

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Text Normalization for Natural Language Processing (NLP)

When we normalize text, we attempt to reduce its randomness, bringing it closer to a predefined “standard”.

The technicians wrote 804 different maintenance

These were reduced to only 173 (80% less)



Original Text	Text Normalized
Change Silica gel Breather	Change Silica gel Breather
Change Silica gel Breather ATR Phase A	
Change Silica gel Breather ATR2	
Change Silica gel Breather Saturation>75%	
Change Silica gel Breather OLTC	
Change Silica gel Breather RL	
Change Silica gelbreather	

Text Normalization for Natural Language Processing (NLP)

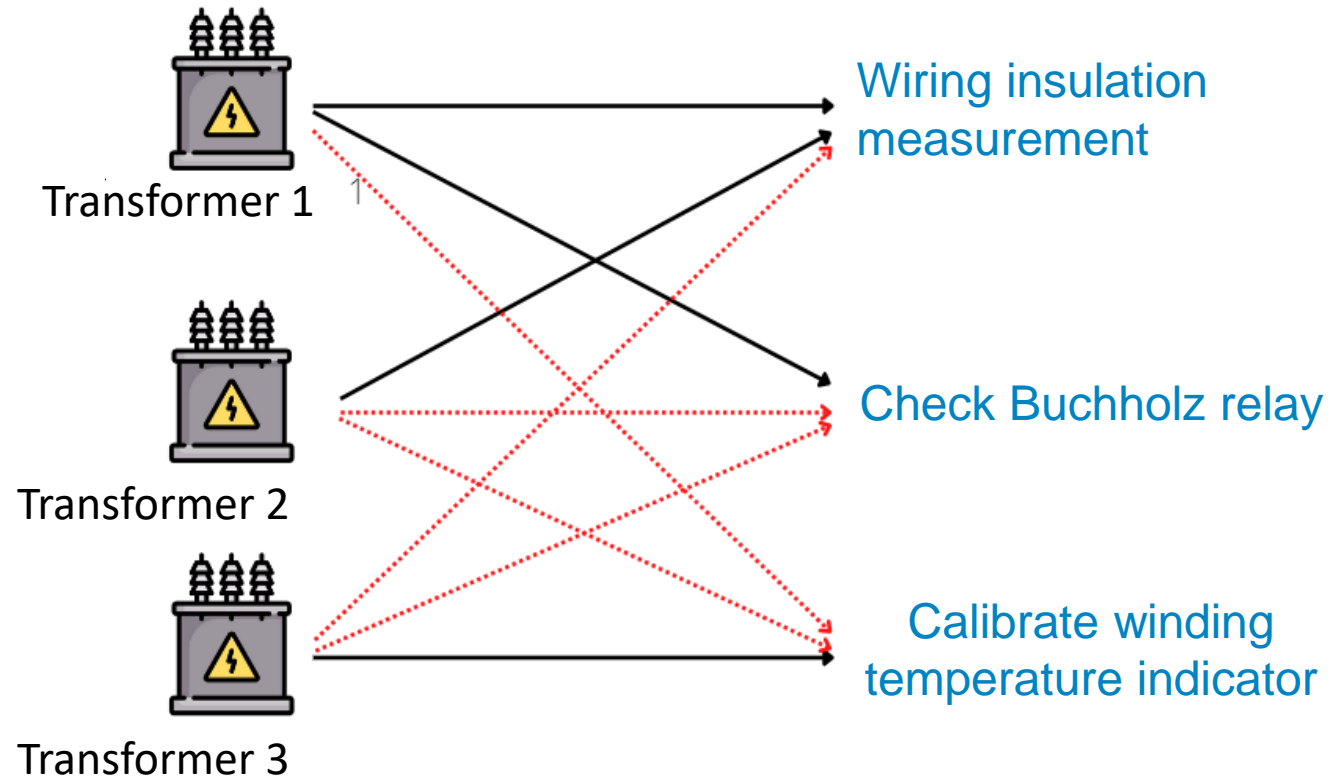
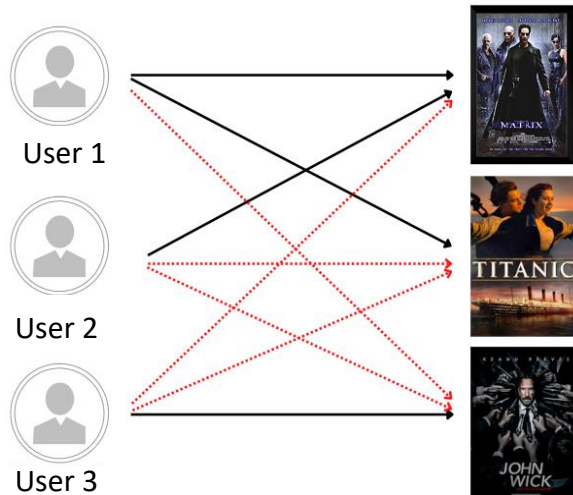
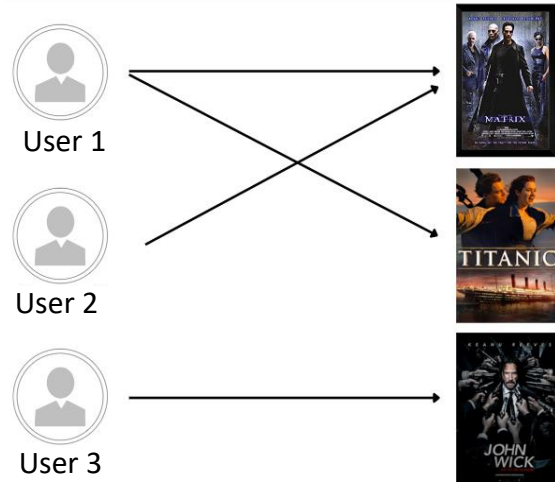
Various techniques were used to standardize the text and reduce the amount of different maintenance.

- The creation of dictionaries with keywords that were repeated and allowed to identify the maintenance.
- The Levenshtein distance algorithm measures differences in words that are difficult to recognize by dictionaries.
- Text normalization involves removing words that are deemed unnecessary for understanding the information.

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How Do Recommender Systems Work



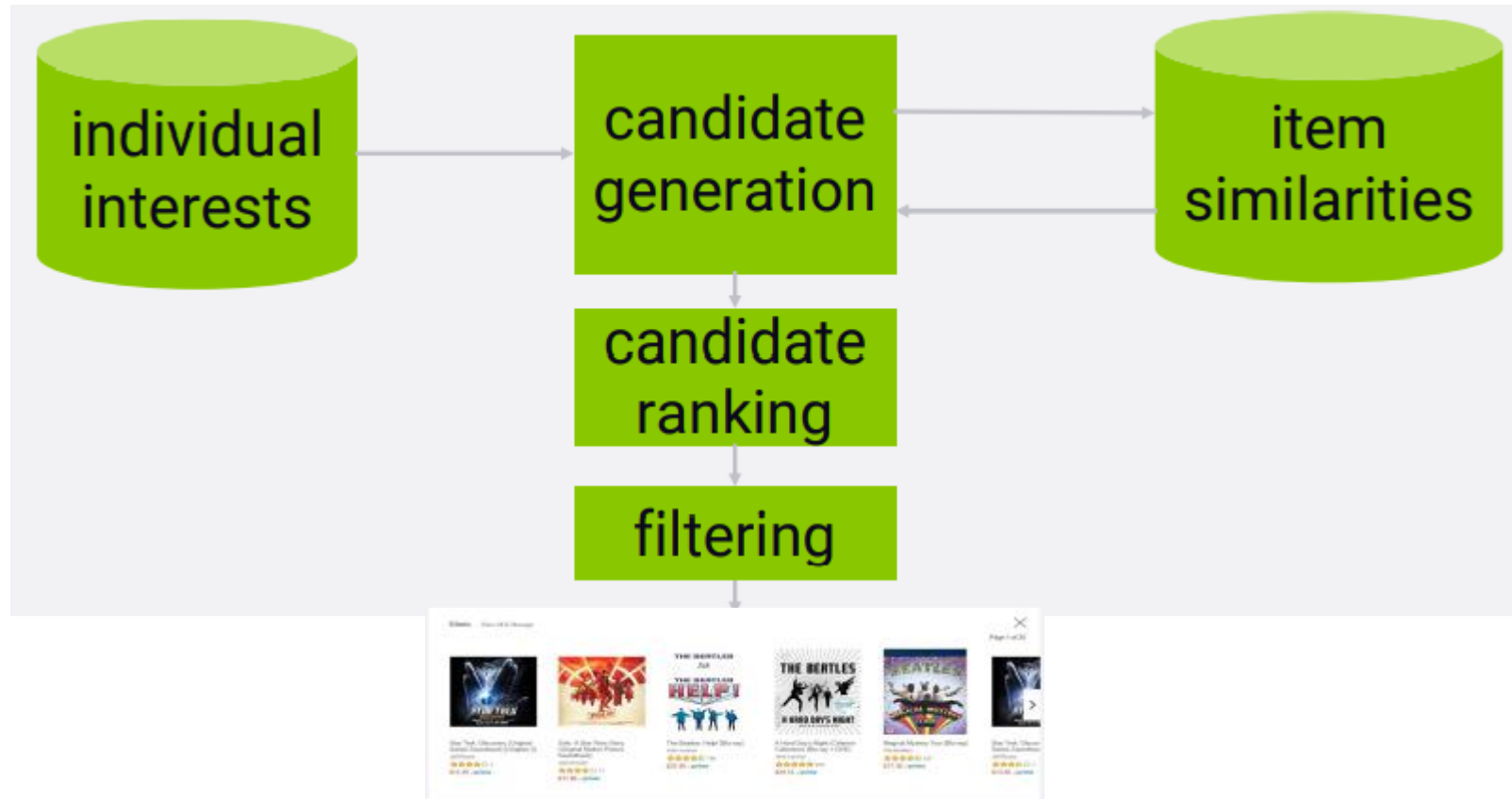
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Anatomy of a top-N recommender

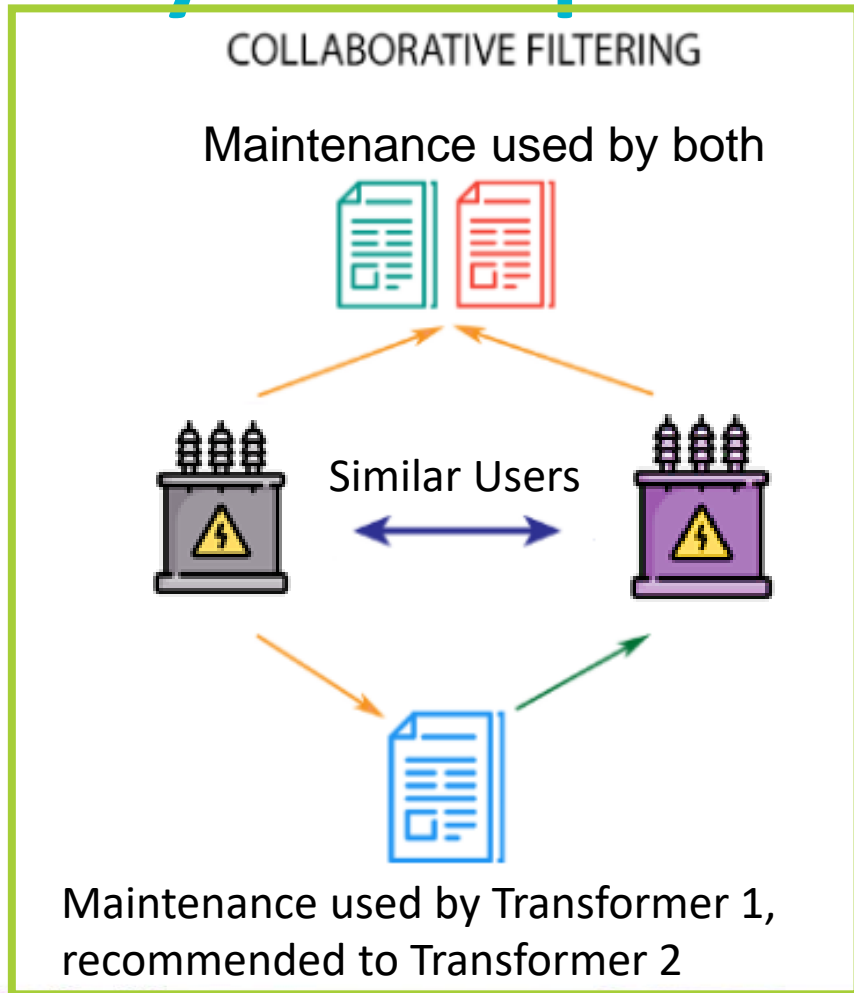


[1]. Building Recommender Systems with Machine Learning and AI: Help people discover new products and content with deep learning, neural networks, and machine learning recommendations. Book by Frank Kane

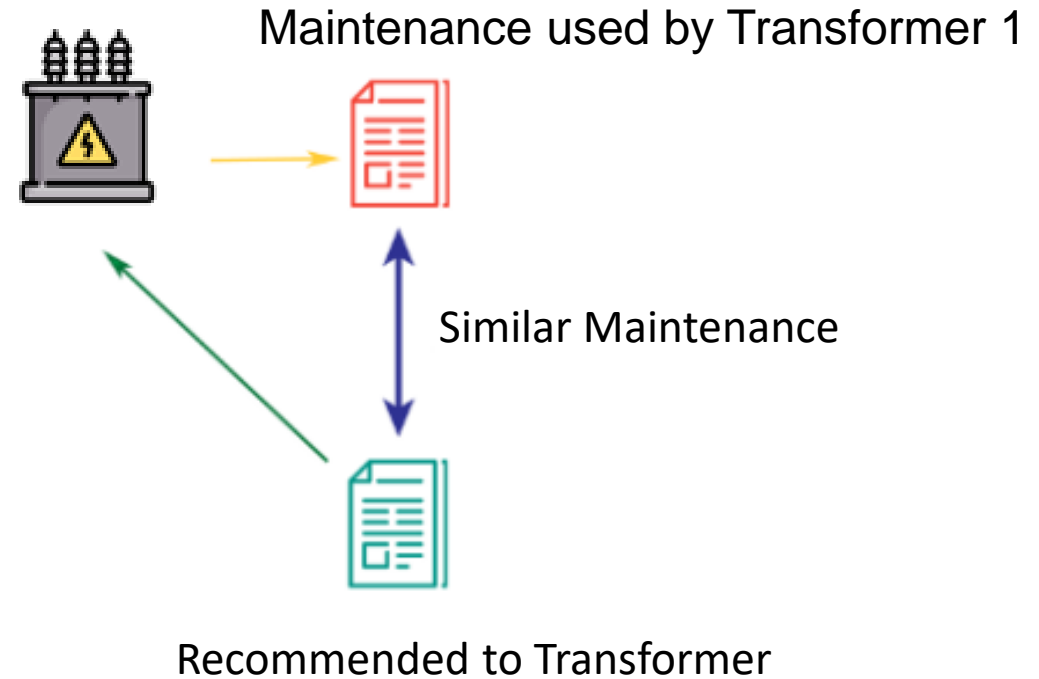
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Anatomy of a top-N recommender



CONTENT-BASED FILTERING



Singular Value Decomposition (SVD)

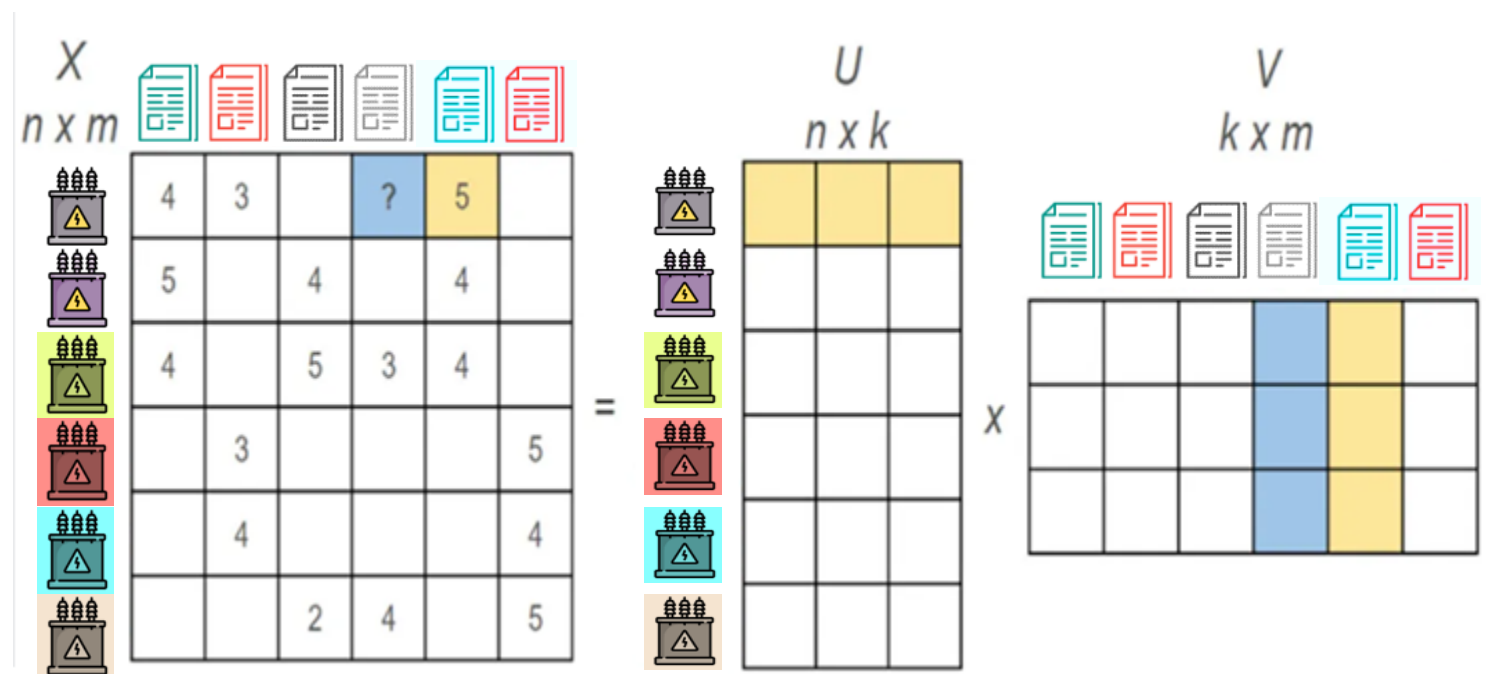
It is the model used to obtain the classifications

It is based on the ratings that other users give to dictate new ratings.

n: Users who recommend

m: Recommendations to make

k: Depth (How many similarly rated users does the model need)



Gathering Ratings

Explicit

- Ask people “Power Transformer” to rate items.

Implicit

- Learn ratings from user actions.



In our case, it is based on the frequency of each maintenance action.

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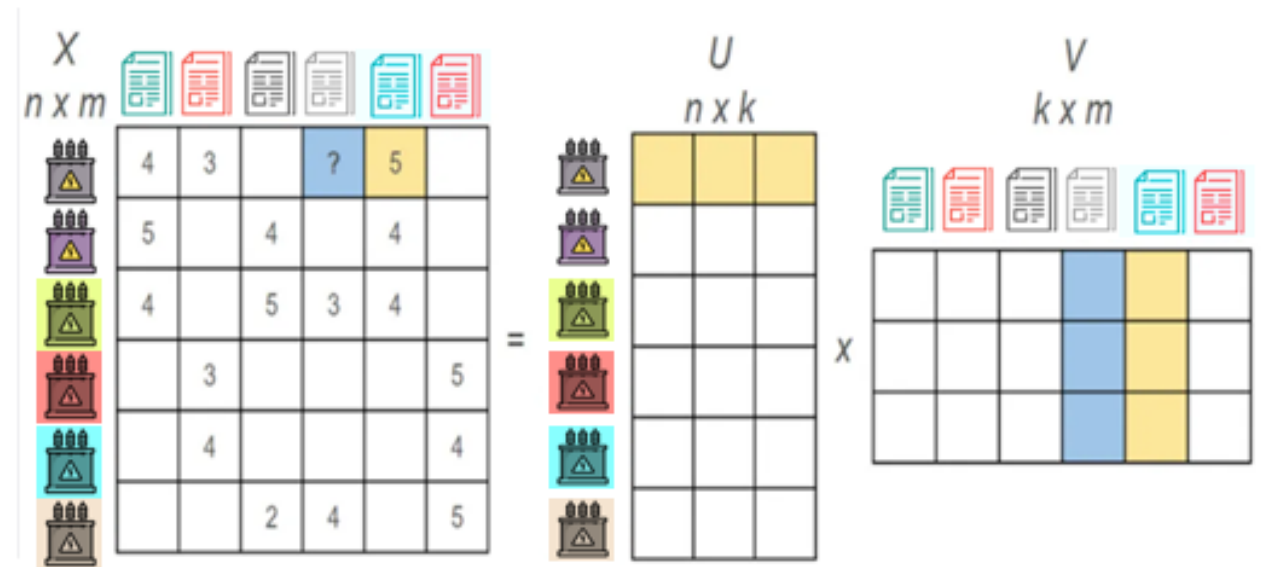
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Singular Value Decomposition (SVD)

It is the model used to obtain the classifications

$$M = U \Sigma V^T$$

- M is the matrix that we want to decompose (m x n)
- U is a unitary matrix of eigenvectors (m x m)
- Σ rectangular matrix, diagonal with eigenvalues (m x n)
- V is a right unitary matrix of eigenvectors (n x n)



The matrix V is calculated by solving the following system of known matrices:

$$V = \frac{1}{\Sigma * M^T * U}$$

Singular Value Decomposition (SVD)

It is the model used to obtain the classifications

$$M = U \Sigma V^T$$

$$M = \begin{bmatrix} 1 & ? & 3 \\ 2 & 5 & ? \\ 7 & ? & ? \end{bmatrix}$$

- Our matrix M is going to have many missing values because the users have not qualified all the items. This is where we start to iterate to solve the system.

To find these values, we can use:

- Traditional algorithms (computationally slow)
- convex optimization
- **Neural networks (Simon Funk's algorithm)**

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The User Interface

Recomendador de Acciones de Mantenimiento



Fecha: 29/04/2014 - 19/12/2020

Calificación Equipo: Seleccionar todo, 2

Equipo: 808997

Modo De falla: PRO-M

Recomendaciones

Equipo	Ubicac.técnica	Denominación	Fabricante	Calificacion texto	Calificacion numerica	Recomendacion
808997	VAL_PAT	Valledupar 2 100 MVA 220/110 kV	PAUWELS	/9-OIL.TAP//2-INSP=9-ENF/2-PRO-M/8-P.CUB/	2	cambiar aspa motoventilador
808997	VAL_PAT	Valledupar 2 100 MVA 220/110 kV	PAUWELS	/9-OIL.TAP//2-INSP=9-ENF/2-PRO-M/8-P.CUB/	2	cambiar termometro temperatura
808997	VAL_PAT	Valledupar 2 100 MVA 220/110 kV	PAUWELS	/9-OIL.TAP//2-INSP=9-ENF/2-PRO-M/8-P.CUB/	2	cambiar transformador potencia
808997	VAL_PAT	Valledupar 2 100 MVA 220/110 kV	PAUWELS	/9-OIL.TAP//2-INSP=9-ENF/2-PRO-M/8-P.CUB/	2	proteccion mecanica
808997	VAL_PAT	Valledupar 2 100 MVA 220/110 kV	PAUWELS	/9-OIL.TAP//2-INSP=9-ENF/2-PRO-M/8-P.CUB/	2	revisar disparo deshabilitado



Failure Mode

Top N, Maintenance are Recommended



Aviso Cerrado

Avisos Previos

Si

Aviso	Equipo	Descripción	Modo Falla	Fecha de cierre	Creado el	Fin deseado	Inicio deseado
232252	808997	Cambiar empaques y silica ATR 1 Dispac	PRO-M	jueves, 31 de marzo de 2011	viernes, 25 de marzo de 2011	viernes, 25 de marzo de 2011	viernes, 25 de marzo de 2011
231474	808997	Cambiar silicagel ATR R	PRO-M	viernes, 29 de abril de 2011	miércoles, 09 de marzo de 2011	miércoles, 06 de abril de 2011	miércoles, 06 de abril de 2011
232227	808997	CAMBIAR SILICA GEL ATR2	PRO-M	viernes, 06 de mayo de 2011	jueves, 24 de marzo de 2011	miércoles, 20 de abril de 2011	miércoles, 20 de abril de 2011
468313	808997	Cambiar silica gel por saturación > 75%	PRO-M	martes, 31 de mayo de 2011	martes, 19 de abril de 2011	jueves, 26 de mayo de 2011	martes, 17 de mayo de 2011
702529	808997	Cambiar silica ael por saturación > 75%	PRO-M	martes, 31 de mayo de 2011	martes, 19 de abril de 2011	viernes, 27 de mayo de 2011	martes, 17 de mayo de 2011

Maintenance s are already planned



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What problems are going to be solved?



Support decisions in maintenance always taking into account the data



Knowledge management (KM)



Improve risk management by reducing response times to a failure.

18 days on average to create a maintenance after a failure



Better efficiency in defining maintenance actions

277 days on average to change the condition

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Next Steps

1) Automate data extraction from our ERP



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Next Steps

2) Automate data extraction from our ERP

The recommendation and maintenance processes are easily linked.



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Next Steps

3) Personalization of the recommendation can help to improve the model.

 Amazon.com
Para: Usted

← ↶ → ...
Jue 31/03/2022 8:10 PM

Hola elkin:

¿Buscas algo en [Equipo de Natación](#)? Tenemos algunas sugerencias para ti.




Gafas de natación polarizadas, antivaho, anti UV, sin fugas, visión...
US\$ 18.99 - US\$ 21.99

[Compra ya](#)



Noticias que quizá se haya perdido

 SharePoint Online <no-reply@sharepointonline.com>
Para: ELKIN LEONARDO CANTOR HUÉRFANO

↶ Responder ↷ Responder a todos → Reenviar ...
lunes 16/05/2022 5:20 a. m.

Correo Externo - Este correo electrónico se originó desde fuera de la organización. No haga clic en enlaces ni abra archivos adjuntos a menos que reconozca al remitente y sepa que el contenido es seguro. Si hay problemas con el modo en que se muestra este mensaje, haga clic aquí para verlo en un explorador web. Haga clic aquí para descargar imágenes. Para ayudarle a proteger su confidencialidad, Outlook ha impedido la descarga automática de algunas imágenes en este mensaje.


Hola, **ELKIN LEONARDO CANTOR HUÉRFANO**

Aquí hay algunas noticias que puede que te hayas perdido la semana pasada.

[Ver todas las noticias](#)

Equipos Inductivos CTEs - DM ISA INTERCOLOMBIA De compañeros con los que trabaja

Equipos Cuestionados
Enlace a los Equipos Cuestionados



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Questions ?

Thanks

Elkin Cantor

ecantor@intercolombia.com

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