

DSCI-558: Building Knowledge Graphs Spring 2021

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UNIVERSITY OF SOUTHERN CALIFORNIA

Who's Teaching This Course?



Jay Pujara



Craig Knoblock



Minh Pham

What is a knowledge graph?

From kgtutorial.github.io

What is a knowledge graph?

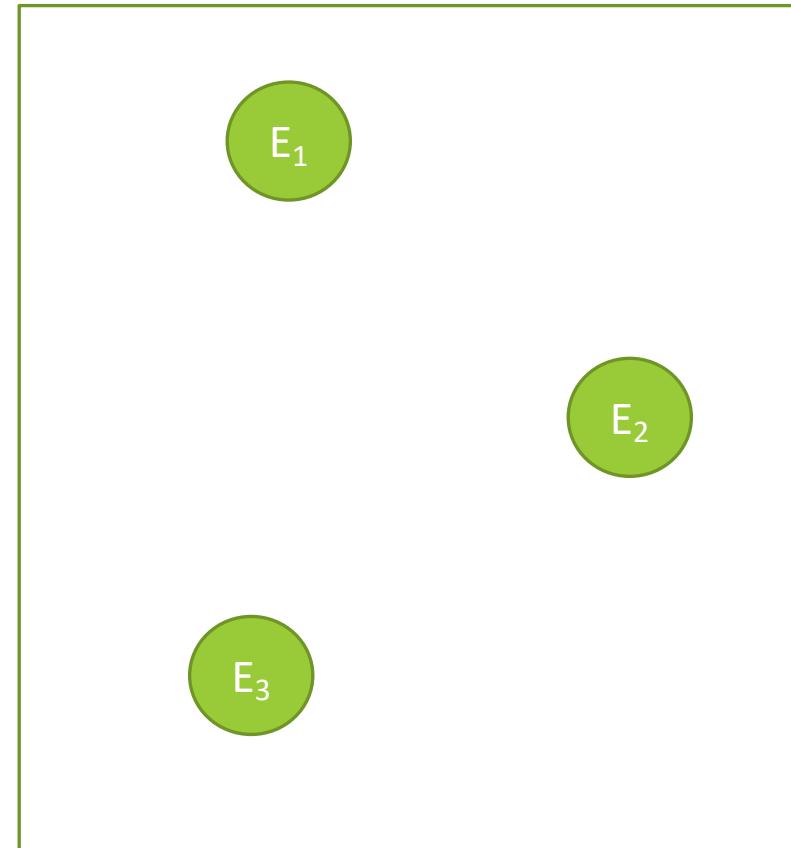
- Knowledge in graph form!

What is a knowledge graph?

- Knowledge in graph form!
- Captures entities, attributes, and relationships

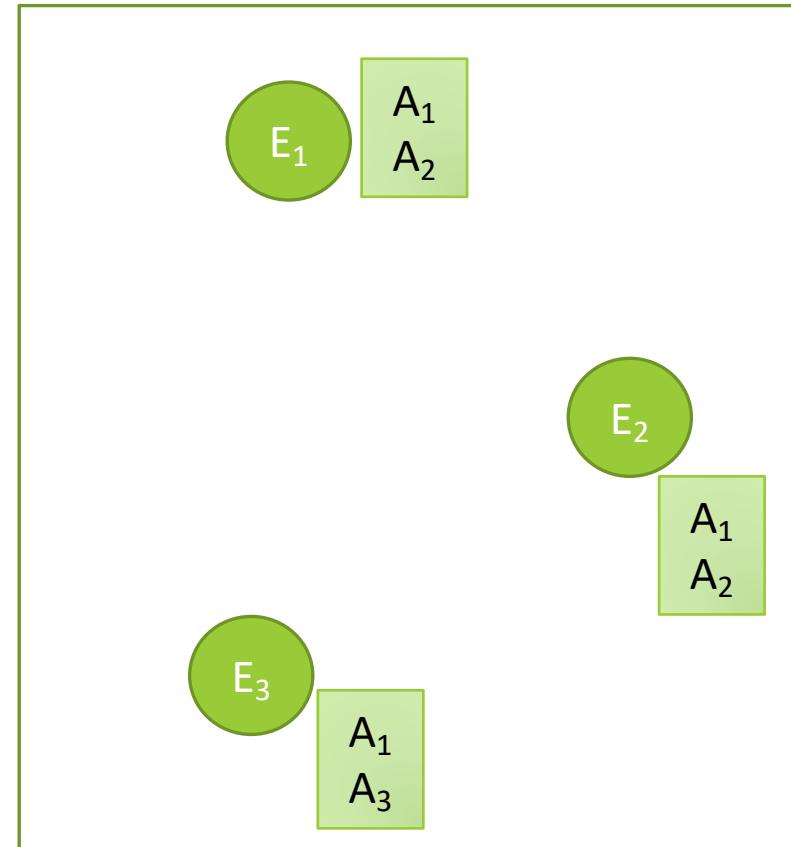
What is a knowledge graph?

- Knowledge in graph form!
- Captures entities, attributes, and relationships
- Nodes are entities



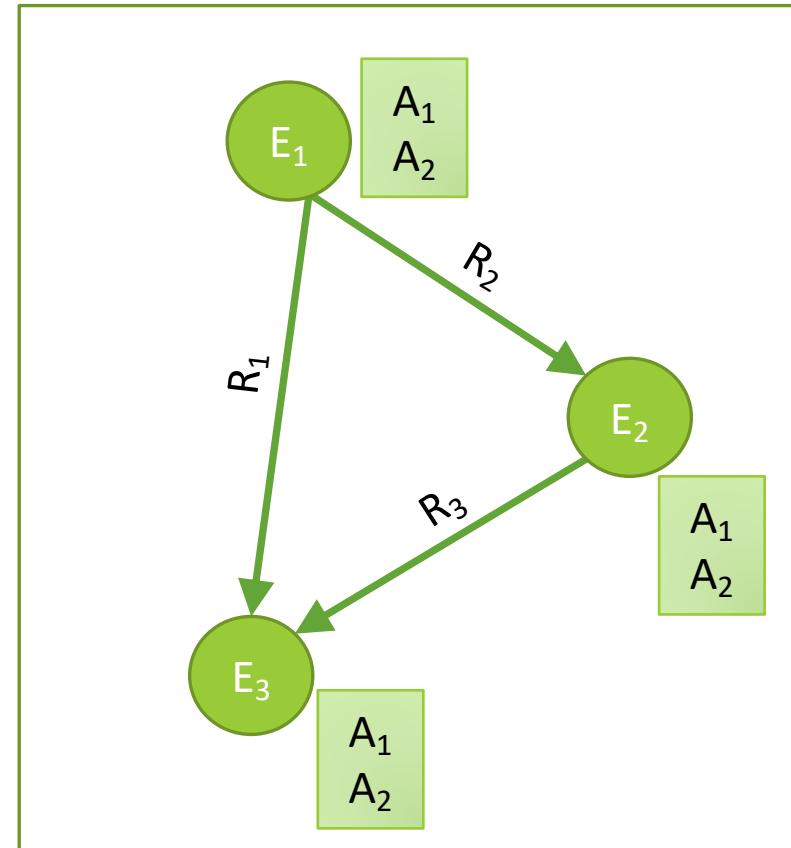
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- Knowledge in graph form!
- Captures entities, attributes, and relationships
- Nodes are entities
- Nodes are labeled with attributes (e.g., types)



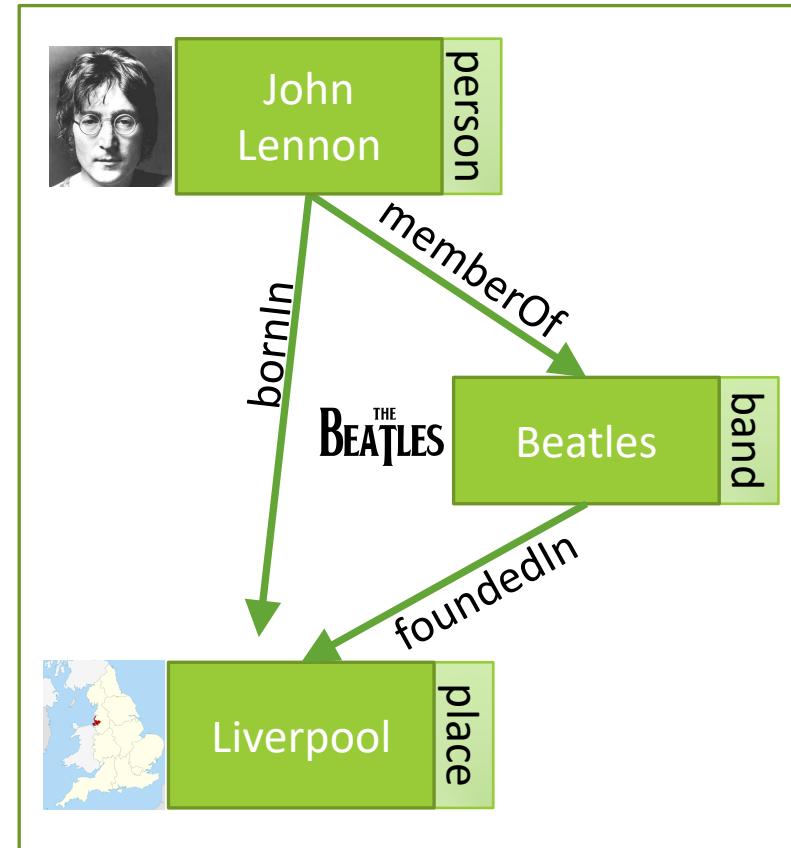
What is a knowledge graph?

- Knowledge in graph form!
- Captures entities, attributes, and relationships
- Nodes are entities
- Nodes are labeled with attributes (e.g., types)
- Typed edges between two nodes capture a relationship between entities



Example knowledge graph

- Knowledge in graph form!
- Captures entities, attributes, and relationships
- Nodes are entities
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Why knowledge graphs?

- Humans:
 - Combat information overload
 - Explore via intuitive structure
 - Tool for supporting knowledge-driven tasks
- AIs:
 - Key ingredient for many AI tasks
 - Bridge from data to human semantics
 - Use decades of work on graph analysis

Applications 1: QA/Agents



The screenshot shows a search results page for "who is playing in this year's super bowl".

- Search bar: "who is playing in this year's super bowl".
- Navigation tabs: All, News, Shopping, Videos, Maps, More, Settings, Tools.
- Text: "About 4,350,000 results (0.46 seconds)".
- Section: "Super Bowl LII".
- Text: "NFL · Today, 3:30 PM".
- Team logos:
 - Philadelphia Eagles (eagle)
 - New England Patriots (Patriot logo)
- Text: "Philadelphia Eagles at New England Patriots Super Bowl".
- Links:
 - Game preview (YouTube icon)
 - Watch on: NBC
- Text: "All times are in Pacific Time".
- Feedback link.

Applications 2: Decision Support

IBM Watson Knowledge Studio

View Details Attribute View View Guidelines Completed Close Alpha... 14pt 1 Entity Mention

2004-49-168A.txt

Mention Relation Reference

1 V₁, a 1999 Toyota Camry, was traveling southbound in the second lane of a four-lane divided (seven lanes overall, divided by raised median), concrete roadway, approaching an intersection.

2 V₂, a 2004 Mercedes S430, was northbound in the fourth lane of a four-lane, divided (seven lanes overall, divided by raised median), concrete roadway, about to turn left into westbound traffic at the same intersection.

3 As both vehicles entered the intersection, the front of V₁ impacted the front of V₂.

4 V₁ rotated clockwise as V₂ rotated counter-clockwise, and the left side of V₁ impacted the right side of V₂ in a sideslap configuration.

5 Both vehicles moved southwest to final rest.

6 Both vehicles were towed due to damage.

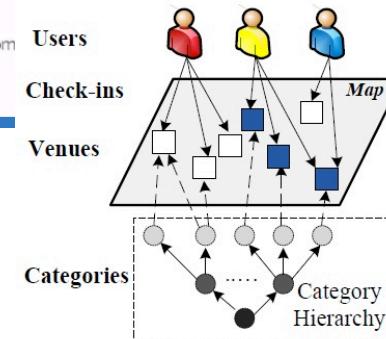
7 The unrestrained driver of V₁ was hospitalized with foot and rib fractures as well as a liver laceration.

8 The restrained driver of V₂ was treated and released with minor abrasion and contusion as well as a finger fracture.

9 The restrained front right passenger in V₂ was pronounced brain dead two days later from brain injuries.

10 V₁ was equipped with redesigned dual frontal airbags which deployed.

Type	Subtype	Role
a	ACCIDENT_CAUSE	
o	ACCIDENT_OUTCOME	
c	CONDITION	
i	IMPACT	
f	MANUFACTURER	
m	MODEL	
y	MODEL_YEAR	
j	PART_OF_CAR	
p	PERSON	
s	STRUCTURE	
v	VEHICLE	



Applications 3: Fueling Discovery

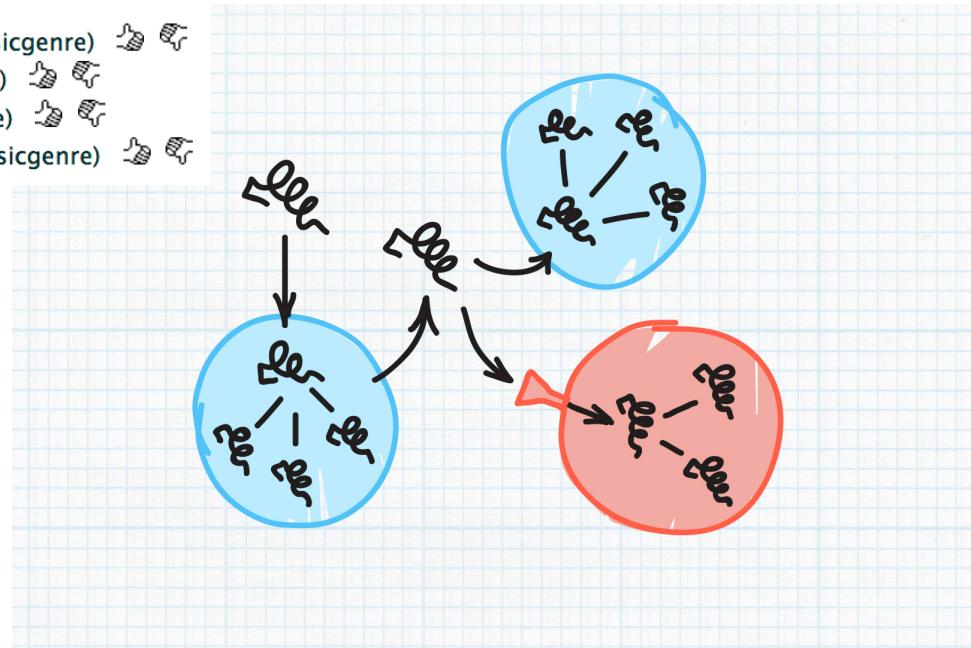
beatles (musicartist)

literal strings: BEATLES, Beatles, beatles

Help NELL Learn!

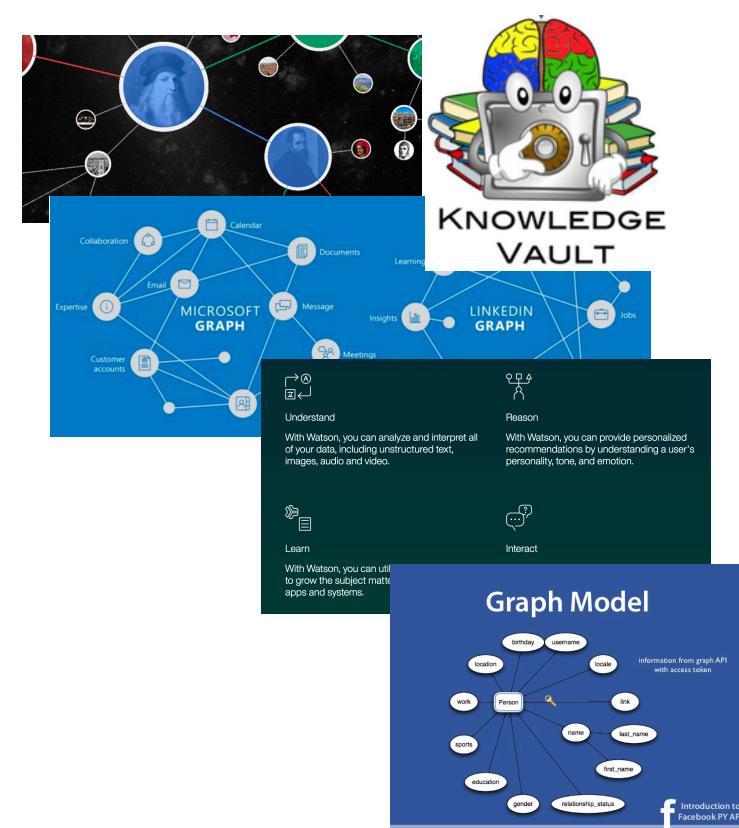
NELL wants to know if these beatles
If they are or ever were, click thumbs-up. Otherwise, thumbs-down.

- beatles is a musical artist  
- beatles is a musician in the genre classic pop (musicgenre)  
- beatles is a musician in the genre pop (musicgenre)  
- beatles is a musician in the genre rock (musicgenre)  
- beatles is a musician in the genre classic rock (musicgenre)  



Knowledge Graphs & Industry

- Google Knowledge Graph
 - Google Knowledge Vault
- Amazon Product Graph
- Facebook Graph API
- IBM Watson
- Microsoft Satori
 - Project Hanover/Literome
- LinkedIn Knowledge Graph
- Yandex Object Answer
- Diffbot, GraphIQ, Maana, ParseHub, Reactor Labs, SpazioDati



Where do knowledge graphs come from?

Where do knowledge graphs come from?

- Structured Datasets
 - Wikipedia Infoboxes, tables, databases, social nets

The Beatles								
The "Fab Four" Beatles lineup in 1964. Clockwise from top left: John Lennon, Paul McCartney, Ringo Starr and George Harrison								
Background information								
Origin	Liverpool, England, United Kingdom							
Genres	Rock · pop							
Years active	1960–1970							
Labels	EMI · Polydor · Swan · Vertigo · United Artists							
Associated acts	The Quarrymen · The Silver Beetles · The Beatles							
Website	thebeatles.com							
Past members	John Lennon · Paul McCartney · George Harrison · Ringo Starr							
Beatles Total Album Sales Statistics								
Total number of Beatles albums sold	2,303,500,000							
Total Albums Sold on iTunes	785,000							
Total Singles Sold on iTunes	3,800,000							
Sales By Available Markets								
United States	209.1 Million							
Preston · Farnworth · Liverpool · Manchester · Birmingham · London	13.6 Million							
United Kingdom	7.5 Million							
Germany	7.3 Million							
France	3.1 Million							
Australia	2.8 Million							
Japan	1.9 Million							
Argentina	1.6 Million							
Brazil	600,000							
Sweden	584,000							
Austria	570,000							
Switzerland	450,000							
ADVERTISEMENT								
Beatles Billboard Chart Statistics								
Total weeks on chart	1,278 weeks							
Total number ones	15							
Total weeks at number one	175 weeks							
Album with longest time spent at number one ("Please Please Me")	30 weeks							
PREV DATA SET	NEXT DATA SET							

Where do knowledge graphs come from?

- Structured Text
 - Wikipedia Infoboxes, tables, databases, social nets
 - Unstructured Text
 - WWW, news, social media, reference articles

Beatles last live performance

Published: Thursday, January 26th 2017, 5:24 am PST

Updated: Monday, January 30th 2017, 4:06 am PST

Written by Jim Eftink, Producer [CONNECT](#)



(KFVS) - How about a little Beatles history.

It was on this date in 1969, the band performed their last live public performance.

Allan Williams, First Manager of the Beatles, Dies at 86

(Source: Stock im^c By ALLAN KOZINN DEC. 31, 2016)

The Beatles
January 17 at 10:00am · 48

The Harrison family is proud to announce the release of George Harrison - The Vinyl Collection box set featuring all of George Harrison's solo studio albums in one collection for the first time.

WO GEORGE HARRISON - THE VINYL COLLECTION
Released on 24th February, 2017, the vinyl box set includes all twelve of George's studio albums with exact replicas of the original release track listing and artwork. Also included in the box set are George's classic live album Live In Japan [2L... See More

 George Harrison - The Vinyl Collection - Released February 24th 2017
George Harrison - The Vinyl Collection, available to pre-order now with an exclusive & limited edition...
[YOUTUBE.COM](#)

 Like  Comment  Share

like love wow! 3K Top Comments

908 shares

 Write a comment... 

Jeffrey Smith What I would really be interested in is an "All Things Must Pass...Stripped Down" with just the basic tracks without Phil Spector's Wall of Sound. I bet it would sound really good and I would buy it in a heartbeat.
Like · Reply · [#ike31](#) · January 17 at 10:20pm

 17 Replies
Dave Matthews I can just see the greedy Harrison family and the greedy music industry multimillionaire big wigs rubbing their hands with glee once more whilst discussing various methods to make people buy their already bought and paid for record collections all... See More
Like · Reply · [#ike26](#) · January 17 at 10:19pm · Edited
 30 Replies



anager of the Beatles in 1960, he sent them on a stint in Germany to hone their stagecraft. Press Association, via Associated Press

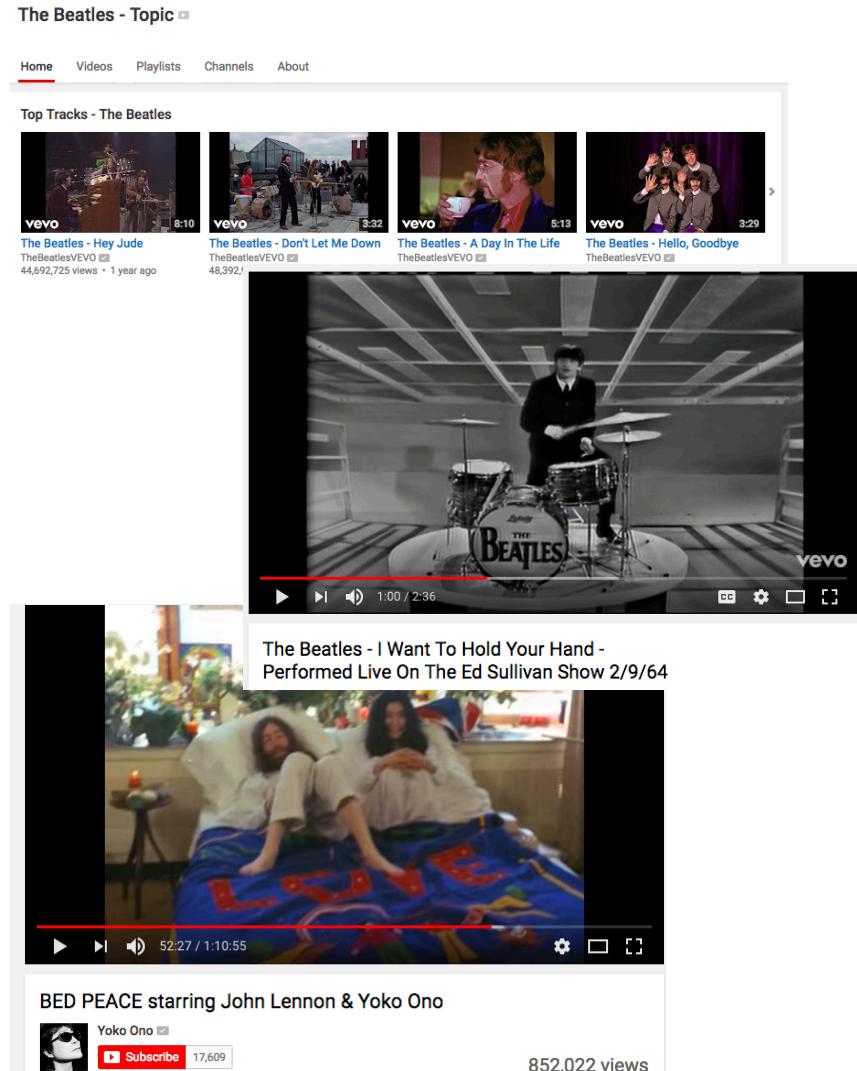
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 - WWW, news, social media, reference articles
- Images

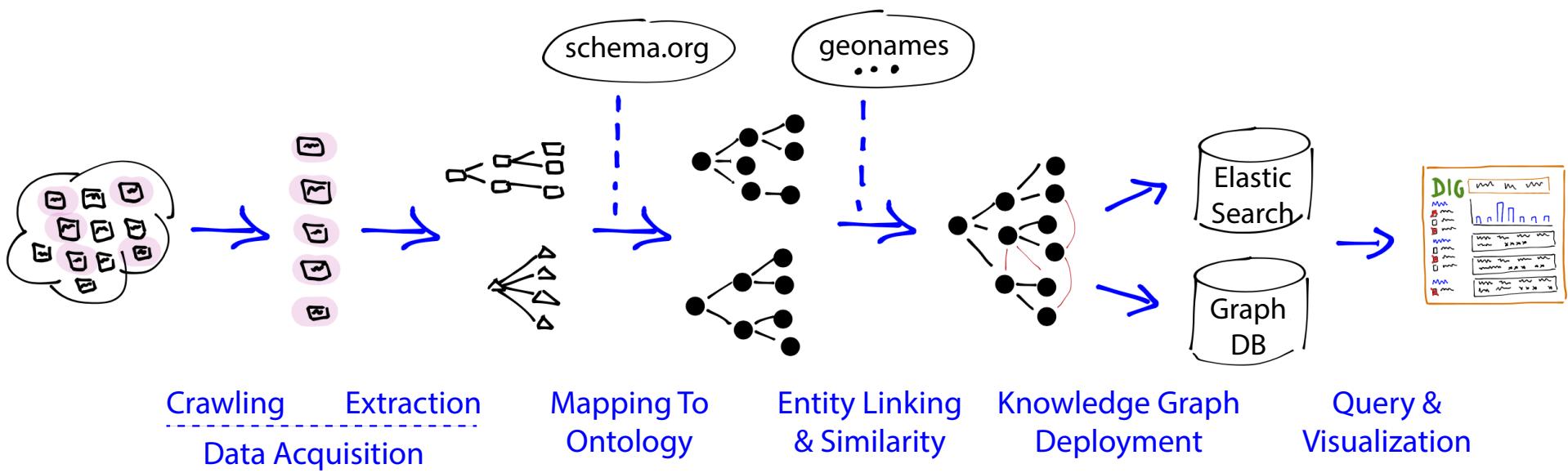


Where do knowledge graphs come from?

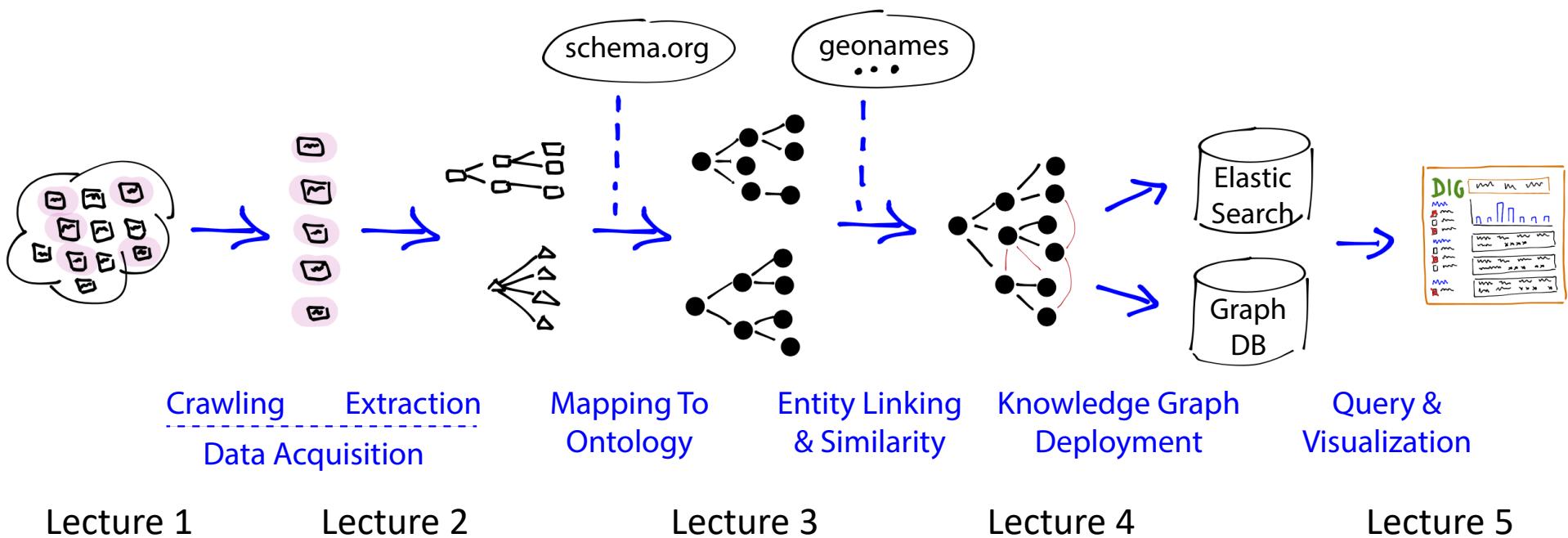
- Structured Text
 - Wikipedia Infoboxes, tables, databases, social nets
- Unstructured Text
 - WWW, news, social media, reference articles
- Images
- Video
 - YouTube, video feeds



Canonical Architecture



QuickStart: Shallow Introduction



Scenario: KG of Art

The screenshot shows a search results page for "Ellsworth Kelly". At the top, there is a grid of images featuring a portrait of the artist and several of his abstract artworks. Below the grid, the artist's name is displayed in large bold letters, followed by the subtitle "American painter". A "More Images" button is located at the bottom right of the grid.

Ellsworth Kelly

American painter

Ellsworth Kelly was an American painter, sculptor, and printmaker associated with hard-edge painting, Color Field painting and minimalism. [Wikipedia](#)

Born: May 31, 1923, [Newburgh, NY](#)
Died: December 27, 2015, [Spencertown, New York, NY](#)
On view: [San Francisco Museum of Modern Art](#), [MORE](#)
Periods: Hard-edge painting, Washington Color School, [MORE](#)
Spouse: [Jack Shear](#) (m. 1984–2015)
Award: [Praemium Imperiale](#)
Education: [Skowhegan School Of Painting & Sculpture](#), [Pratt Institute](#), [School of the Museum of Fine Arts at Tufts](#)

Artworks

White Curve
1974

Blue Green Red
1963

Colors for a Large Wall
1951

Nine Squares
1971

Green Curve
2000

[View 5+ more](#)

People also search for

Frank Stella

Jasper Johns

Josef Albers

Agnes Martin

Barnett Newman

[View 110+ more](#)

[Show less](#)

[Feedback](#)

See results about

[Line & Color: The Nature of Ellsworth Kelly \(Exhibition\)](#)
Dates: Jun 1, 2018 – Oct 29, 2018
Location: Norton Simon Museum, Pasadena, CA

Task 1: Crawling



Ellsworth Kelly, Blue Red Orange, 1970-1972
Ellsworth Kelly, Blue Red Orange, 1970-1972, lithograph, 30 1/2 in. x 34 5/8 in. (87.63 cm x 88.27 cm). Collection SFMOMA. Bequest of Alfred M. Ehrenberg. © Ellsworth Kelly



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Award: [Premium Importante](#)

Education: Skowhegan School Of Painting & Sculpture, Pratt Institute, School of the Museum of Fine Arts at Tufts

Artworks



THE BROAD
OPEN TODAY 11 A.M. - 8 P.M.

People also search for



Show less

Feedback

See results about

Line & Color: The Nature of Ellsworth Kelly (Exhibition)
Dates: Jun 1, 2018 – Oct 29, 2018
Location: Norton Simon Museum, Pasadena, CA

Ellsworth Kelly

From Wikipedia, the free encyclopedia

Ellsworth Kelly (May 31, 1923 – December 27, 2015)

was an American painter, sculptor and printmaker associated with **hard-edge** painting and **minimalism**. His work uses unassuming techniques emphasizing form, similar to the work of **Johannes** **Kenzo Noland**. Kelly often enlivens his compositions with color.

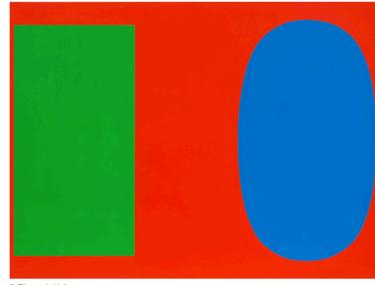
He lived and worked in Spencer, Connecticut.

[Contents \[show\]](#)

Childhood [edit]

Kelly was born the second son

TICKETS VISIT



placement of shapes, energizing the visual experience and creating a disorienting optical effect. The green rectangle and blue oval are vibrant and foreign against the red background. Kelly does not construct balance or resolve; he creates compositions that are alive in their idiosyncrasies.

[Read more about Ellsworth Kelly](#)

ELLSWORTH KELLY
GREEN BLUE RED
1963

oil on canvas
67 1/2 x 90 in. (171.45 x 228.6 cm)

[On View](#)

Accession Date:
01/04/2013

Accession Number:
B-KELLY-2013.001

About this artwork

Throughout the late 1950s and early 60s, Ellsworth Kelly worked with shapes and solid colors deployed flatly across simple canvases. Finding inspiration in both nature and art, he was drawn to the oddity of forms and the various conditions that create visual interest in unlikely ways. In this spirit, *Green Blue Red* abstains from the balance and harmony of traditional painting and reflects an impulse to build a surface of visual tension out of the contrasts of color and shape and the containment of an edge. Kelly's works of this period depict the jarring difference between color and the unusual.

[Read more about Ellsworth Kelly](#)

Not on view

Medium

One from a portfolio of ten screenprints

Dimensions

composition: 21 15/16 x 17 15/16" (55.7 x 45.5 cm); sheet: 23 15/16 x 19 15/16" (60.8 x 50.7 cm)

Publisher

Wadsworth Atheneum, Hartford, CT

This work is part of a collection of 9 other works

Ellsworth Kelly

Red Blue from X + X (Ten Works by Ten Painters)
1964

There are 2 other works

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HW 1: Crawling (out next week)



VISIT ART + ARTISTS RESEARCH EDUCATION ABOUT DONATE

Home / Art + Artists

Red Blue



Ellsworth Kelly, *Red Blue*, 1964, screenprint, Smithsonian American Art Museum, Gift of the Woodward Foundation, 1977.48.28

Zoom

Download

Title	Red Blue
Artist	Ellsworth Kelly
Date	1964
On View	Not on view.
Dimensions	
Copyright	
Credit Line	Smithsonian American Art Museum
Mediums Description	Gift of the Woodward Foundation
Classifications	screenprint
	Graphic Arts
	Print

Smithsonian American Art Museum
Open Daily: 11:30
Renwick Gallery
Open Daily: 10:00

Ellsworth Kelly

Name: Ellsworth Kelly
Born: Newburgh, [New York](#) 1923
Died: Spencertown, [New York](#) 2015
Active in: New York, [New York](#)
Paris, France
Nationalities: American
[Linked Open Data](#)

Artist Biography

Considered a pioneer of hard-edge painting, Ellsworth Kelly is best known for his crisp nonrepresentational works, intensely colored and radically simplified. His early training in the applied art program at Pratt Institute, Brooklyn, was interrupted by his induction into the army in 1943. Art Historian E. C. Goossen has speculated that Kelly's assignment to a camouflage battalion provided him with invaluable lessons about the interaction of form and shadow in space, which were applied later in his collages, paintings, and sculpture.

After studying for two years at the School of the Museum of Fine Arts in Boston, Kelly went to Paris in 1948 to attend the École des Beaux-Arts until 1950. In France he encountered the works of Pablo Picasso, Henri Matisse, Jean Arp, and Piet Mondrian. His figurative work subsequently gave way to increasingly abstract paintings in which curvilinear and rectilinear forms suggest fragments of visual phenomena such as architectural elements and shadows.

In 1950 he began to explore the random selection of color and form by using collages, composed of torn details of his drawings, as the basis for his paintings. While in France Kelly also produced grid paintings built on modular and serial systems. By 1952 these concerns were expressed in large multipanel paintings in which each panel was a module of color. Kelly's concern with color as form was thus established.

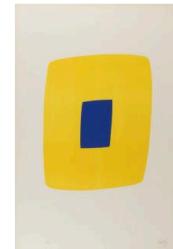
After returning to the United States in 1954, Kelly worked with large single biomorphic shapes in black and white. Primary colors reappeared in his paintings after 1957, either in double or triple variations or singly in contrast with white, as in *Blue on White* [SAAM, 1969.47.63].

National Museum of American Art (CD-ROM) (New York and Washington D.C.: MacMillan Digital in cooperation with the National Museum of American Art, 1996)

WORKS BY THIS ARTIST



[BLUE ON WHITE](#)



[YELLOW WITH DARK BLUE](#)
[LIGHT YELLOW WITH DARK](#)



[RED BLUE](#)
Ellsworth Kelly



[CYCLAMEN IV](#)
Ellsworth Kelly

HW 2: Extraction



VISIT ART + ARTISTS RESEARCH EDUCATION ABOUT DON

/ your visit

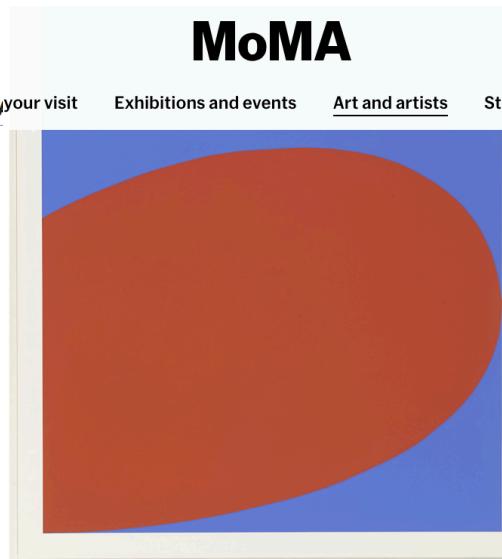
Red Blue



Ellsworth Kelly, *Red Blue*, 1964, screenprint, Smithsonian American Art Museum, Gift of the Woodward Foundation, 1977.48.28

Zoom

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Publisher
Wadsworth Atheneum, Hartford, CT

COLLECTION ONLINE

ARTISTS DATES MEDIUMS MOVEMENTS VENUES SPECIAL COI

Ellsworth Kelly

B. 1923, NEWBURGH, NEW YORK; D. 2015, SPENCERTOWN, NEW YORK
Ellsworth Kelly was born in 1923 in Newburgh, New York. He studied at Pratt Institute, Brooklyn, from 1941 to 1943. After military service from 1943 to 1945, he attended the School of the Museum of Fine Arts, Boston, from 1946 to 1948. In 1949, Kelly went to France and enrolled at the École des beaux-arts, Paris, under the GI Bill, although he attended classes infrequently. In France, he discovered Romanesque art and architecture as well as Byzantine art. He was also introduced to Surrealism and Neo-Plasticism, which led him to experiment with automatic drawing and geometric abstraction. In his work Kelly abstracts the forms in his paintings from observations of the real world, such as shadows cast by trees or the spaces between architectural elements.

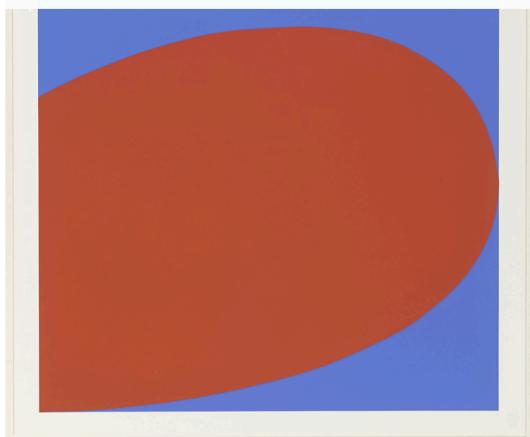
In 1950, Kelly met Jean Arp and that same year began to make shaped-wood reliefs and collages in which elements were arranged according to the laws of chance. He soon began to make paintings in separate panels that could be recombined to produce alternate compositions, as well as multipanel paintings in which each canvas is painted a single color. During the 1950s, he traveled throughout France, where he met Constantin Brancusi, Alexander Calder, Alberto Magnelli, Francis Picabia, and Georges Vantongerloo, among other artists. His first solo show took place at the Galerie Arnaud Lefebvre, Paris, in 1951.

Kelly returned to the United States in 1954, living first in a studio apartment on Broad Street, New York, and then at Coenties Slip in lower Manhattan, where his neighbors would through the years include Robert Indiana, Agnes Martin, Fred Mitchell, James Rosenquist, Lenore Tawney, and Jack Youngerman. Kelly continued to develop and expand the vocabulary of painting, exploring issues of form and ground with his flatly painted canvases. His first solo show in New York was held at the Betty Parsons Gallery in 1956, and three years later he was included in *16 Americans* at the Museum of Modern Art (MoMA), New York. In 1958, he also began to make freestanding sculptures. In 1959, art historian Jules Langsner termed the current of American geometric abstraction "Hard-edge painting," connoting the shaped panels of bright color and rigid form created by Kelly and his contemporaries. Kelly moved out of Manhattan in 1970 and set up a studio in Chatham and a home in nearby Spencertown, New York; he lived and worked there until his death in 2015.

HW 3: Entity Linking & Semantic Representation



Red Blue, Smithsonian American Art Museum, Gift of

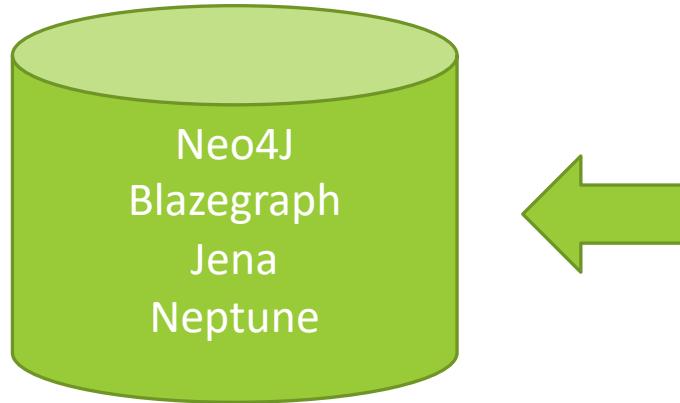


Same?

Zoom

Title	Red Blue	Property	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	Value	http://www.cidoc-crm.org/cidoc-crm/E22_Man-Made_Object
Artist	Ellsworth Kelly				Ellsworth Kelly
Date	1964				Red Blue from X + X (Ten Works by Ten Painters) 1964
http://www.cidoc-crm.org/cidoc-crm/P138i_has_representation					
					
http://www.cidoc-crm.org/cidoc-crm/P1_is_identified_by					
http://www.cidoc-crm.org/cidoc-crm/P102_has_title					
http://www.cidoc-crm.org/cidoc-crm/P30i_custody_transferred_through					
http://www.cidoc-crm.org/cidoc-crm/P48_has_preferred_identifier					
http://www.cidoc-crm.org/cidoc-crm/P50_has_current_keeper					
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lithograph					
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http://edan.si.edu/saam/id/ontologies/PE_object_subclass					
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http://edan.si.edu/saam/id/object/13504/production					

HW 4: Ingest into a KG Platform & Query Engine



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SELECT ?s WHERE {  
    ?s rdf:type creativework .  
}
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HW 5: Queries and Analysis from KG

Who is Ellsworth Kelly
Tap to Edit ➔

Here's some information:

 KNOWLEDGE

Ellsworth Kelly
American painter, sculptor,
and printmaker

 Ellsworth Kelly was an American painter, sculptor, and printmaker associated with hard-edge painting, Color Field painting and minimalism. His works demonstrate unassuming techniques emphasizing line, color and form, similar to the work of John McLaughlin

What is Ellsworth Kelly known for
Tap to Edit ➔

The answer I found is Stele II.

 KNOWLEDGE

Stele II
Artwork by Ellsworth Kelly

 Stele II is an abstract sculpture, constructed in 1973, by Ellsworth Kelly. Located at the National Gallery of Art Sculpture Garden, it reflects the artist's move to the countryside, and landscape.

Established 1973