

# Invariance and Variability of Synonymy Networks

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# Exploring lexical networks

**Multidisciplinary team,**

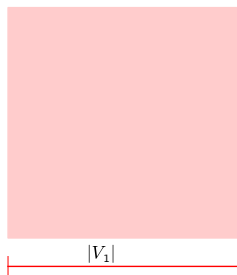
**University of Toulouse: CNRS, IRIT, CLLE-ERSS**

- ▶ NLP: resources building and consolidation: **Wisigoth**  
[Sajous et al., 2010]
- ▶ IR, networks of documents and labels: **KODEX** (Quaero)  
[Navarro et al., 2011]
- ▶ Cognition: lexicon learning dynamics and medical application  
[Gaume et al., 2008], metaphor resolution (**SLAM**)[Desalle et al., 2010]
- ▶ Linguistics: lexical networks and language typology  
[Gaume et al., 2009], Franco-Taiwan **project M3**

**Today: issue of comparing the many lexical networks:**

- ▶ High **variability of synonymy networks** at the edge level...
- ▶ Reliable **resource comparison criterion** ?

# Comparing graphs' vertices

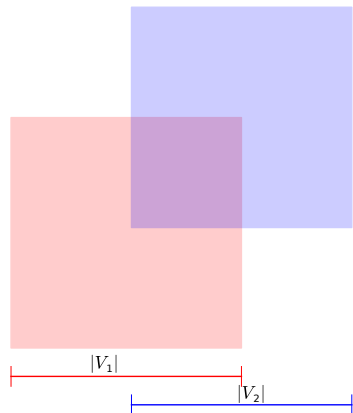


$$G_1 = (V_1, E_1), \quad G_2 = (V_2, E_2)$$

Lexical coverage :

$$R_{\bullet} = \frac{|V_1 \cap V_2|}{|V_2|}, \quad P_{\bullet} = \frac{|V_1 \cap V_2|}{|V_1|}$$
$$F_{\bullet} = 2 \cdot \frac{R_{\bullet} \cdot P_{\bullet}}{R_{\bullet} + P_{\bullet}}$$

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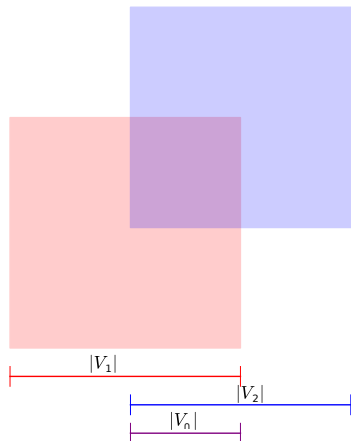


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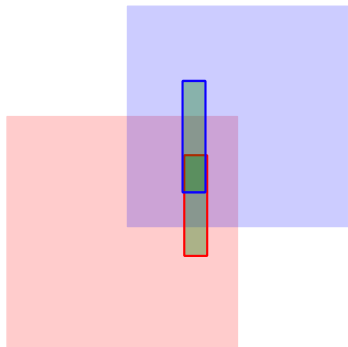


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# Comparing graphs' edges



Reduce graphs to common vertices,

Consider graph as a synonymy judgment,

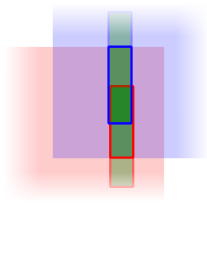
Use **Kappa** to measure inter judge agreement:

$$K_{\downarrow}(G'_1, G'_2) = \frac{(p_0 - p_e)}{(1 - p_e)}$$

$$p_0 = \frac{1}{\omega} \cdot (|E'_1 \cap E'_2| + |\overline{E'_1} \cap \overline{E'_2}|)$$

$$p_e = \frac{1}{\omega^2} \cdot (|E'_1| \cdot |E'_2| + |\overline{E'_1}| \cdot |\overline{E'_2}|)$$

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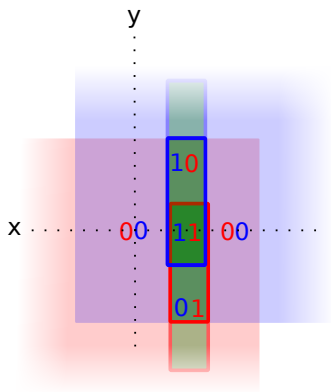
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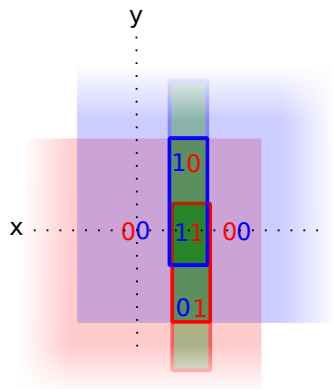
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# Experiment: Comparison of 7 synonymy resources

## 5 French dictionaries:

(General purpose, paper dictionaries)

- ▶ Bailly
- ▶ Benac
- ▶ Bertaud
- ▶ Larousse
- ▶ Robert

## 2 English resources:

- ▶ Wiktionary
- ▶ Princeton Wordnet

	$n$	$m$	$\langle k \rangle$	$n_{lcc}$	$m_{lcc}$	$C$	$L_{lcc}$	$\lambda$	$r^2$
$Bai_V$	3082	3648	2.46	2774	3417	0.04	8.24	-2.33	0.94
$Ben_V$	3549	4680	2.73	3318	4528	0.03	6.52	-2.10	0.96
$Ber_V$	6561	25177	7.71	6524	25149	0.13	4.52	-1.88	0.93
$Lar_V$	5377	22042	8.44	5193	21926	0.17	4.61	-1.94	0.88
$Rob_V$	7357	26567	7.48	7056	26401	0.12	4.59	-2.01	0.93
$PWN_V$	11529	23019	6.3	6534	20806	0.47	5.9	-2.4	0.90
$Wik_V$	7339	8353	2.8	4285	6093	0.11	8.9	-2.4	0.94

# Results: A Weak Agreement ...

$K_{\downarrow}$	$Ben_V$	$Ber_V$	$Lar_V$	$Rob_V$	$Wik_V$
$Bai_V$	0.583	0.309	0.255	0.288	
$Ben_V$		0.389	0.276	0.293	
$Ber_V$			0.416	0.538	
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What's wrong ??

- Why do resources describing the same lexicon appear so different ?

# The picture metaphor (1/2)

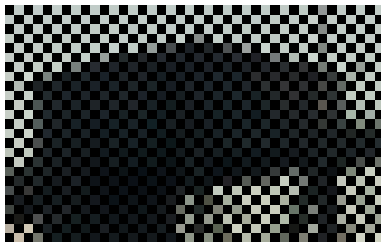


Hawthorne bridge, Portland

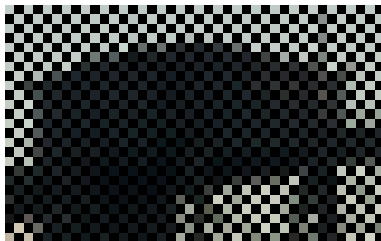
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Hawthorne bridge, Portland



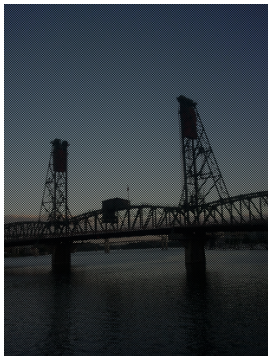
Each **even** pixel painted in black...



Each **odd** pixel painted in black...

## The picture metaphor (2/2)

*Even* =



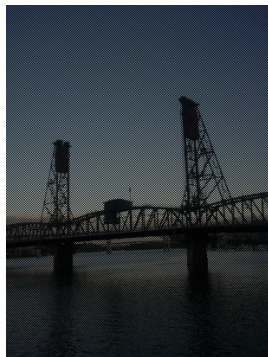


## The picture metaphor (2/2)

*Even* =



*Odd* =



Can you see a difference ?

however...  $\text{sim}(A, B) \approx 0$ , when computed at **pixel level**.

Similarly on graphs: take a step back !

Weak agreement at the **edge level**

but

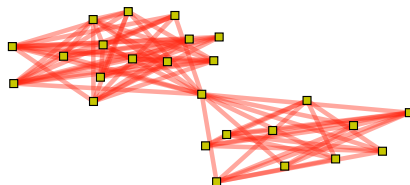
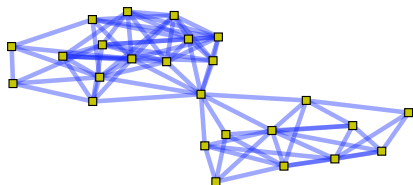
a stronger agreement at a **coarser grain level...**

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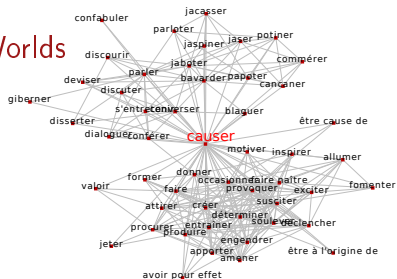


As for the pictures: **no edge in common** between these two graphs.

# How can we look at our graph at different grain levels ?

## Lexical Networks: Hierarchical Small Worlds

- ▶ Low density
- ▶ Short paths
- ▶ Heavy tailed degree distribution
- ▶ High clustering coefficient: **dense zones**

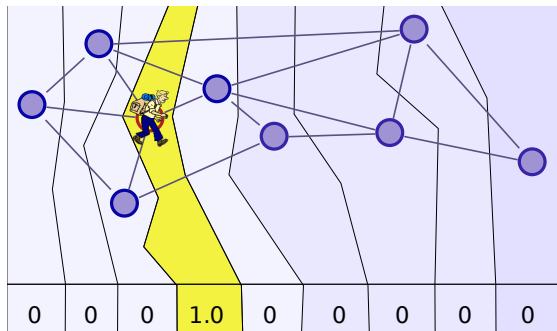


## Random Walks

- ▶ **Idea:** if  $(u, v)$  are in the same “**cluster**”, they may **not** be **adjacent**, but **many shorth paths** lead from  $u$  to  $v$ .
- ▶ Random walkers tend to be trapped into clusters,
- ▶ Note: possible approach for clustering



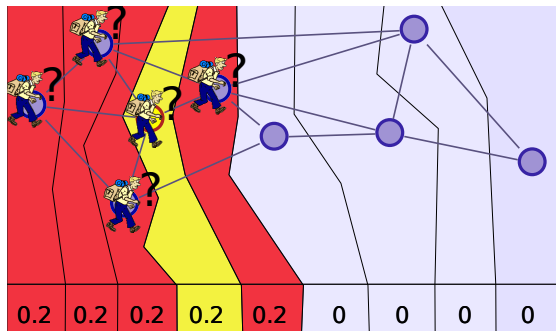
# Random walks on graph...



- 1 start from a node  $u$ ,
- 2 walk to a neighbour with equal probability,
- 3 walk to a neighbour with equal probability,
- 4 etc...

$$t = 0, \quad P^t(u, *) = [0, 0, 0, 1.0, 0, 0, 0, 0, 0]$$

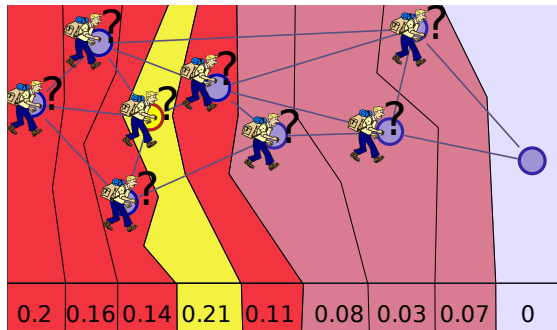
# Random walks on graph...



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$$t = 1, \quad P^t(u, *) = [0.2, 0.2, 0.2, 0.2, 0.2, 0, 0, 0, 0, 0]$$

# Random walks on graph...

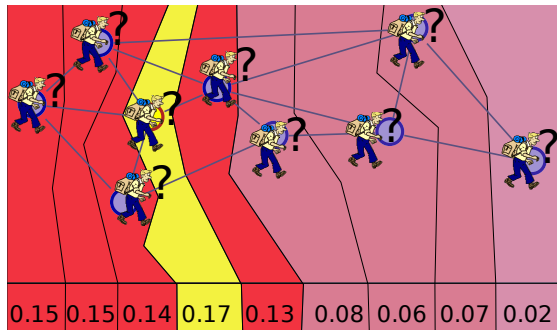


- 1 start from a node  $u$ ,
- 2 walk to a neighbour with equal probability,
- 3 walk to a neighbour with equal probability,
- 4 etc...

$$t = 2, \quad P^t(u, *) = [0.2, 0.16, 0.14, 0.21, 0.11, 0.08, 0.03, 0.07, 0]$$



# Random walks on graph...



- 1 start from a node  $u$ ,
- 2 walk to a neighbour with equal probability,
- 3 walk to a neighbour with equal probability,
- 4 etc...

$$t = 3, \quad P^t(u, *) = [0.15, 0.15, 0.14, 0.17, 0.13, 0.08, 0.06, 0.07, 0.02]$$

# Strong and weak confluence

- **Long walks:** probability of reaching a node  $v$  only depends on  $v$ 's degree:

$$\lim_{t \rightarrow \infty} P^t(u, v) = \frac{\deg(v)}{\sum_{n \in V} \deg(n)} = \pi_v \quad (1)$$

- **Short walks:** high probability of staying in a dense zones:
  - $P_t(u, v) > \pi_v$  if  $u$  et  $v$  in the same cluster: *strong confluence*
  - $P_t(u, v) < \pi_v$  otherwise: *weak confluence*

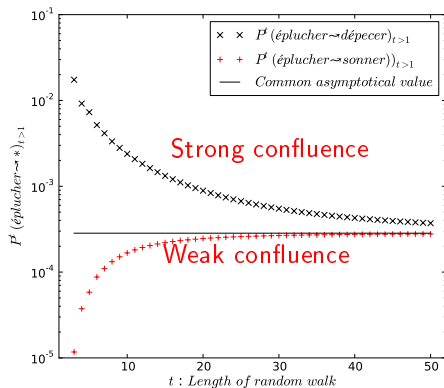


# Illustration of weak and strong confluence (2/2)

In Robert:

*éplucher* (peel)  $\leftrightarrow$  *dépecer* (tear apart)

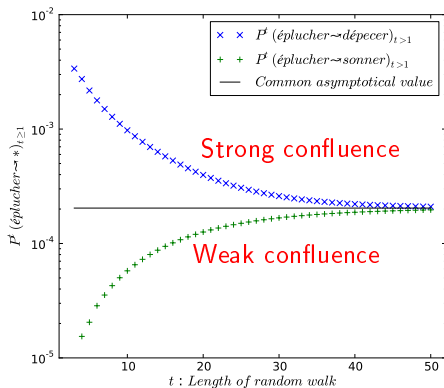
*éplucher* (peel)  $\leftrightarrow$  *sonner* (ring)



In Larousse:

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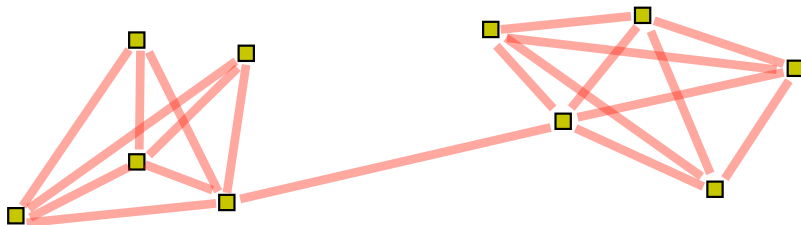
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# Signature of confluence


4 types of pairs of vertices:

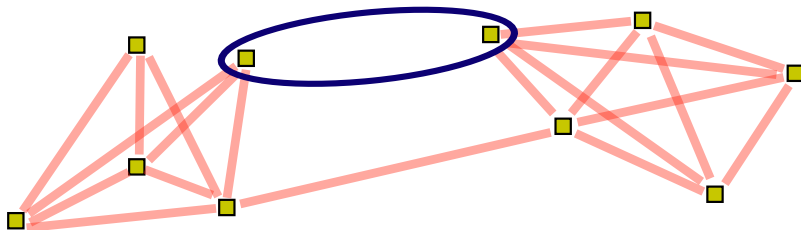
Synonymy	Confluence	
No	weak	Unrelated
No	strong	Potential synonyms
Yes	weak	Shortcut
Yes	strong	Strong synonyms



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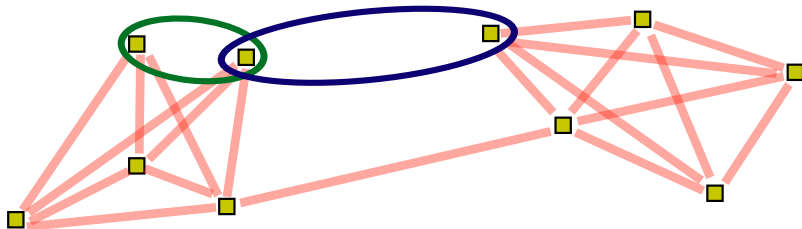
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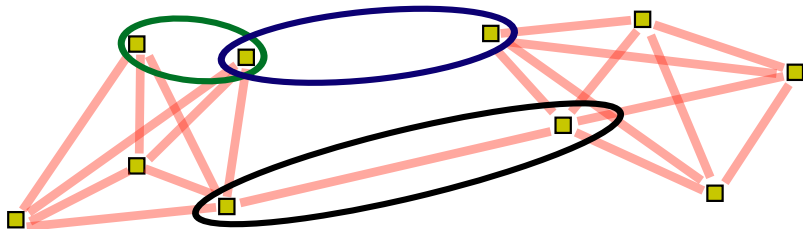
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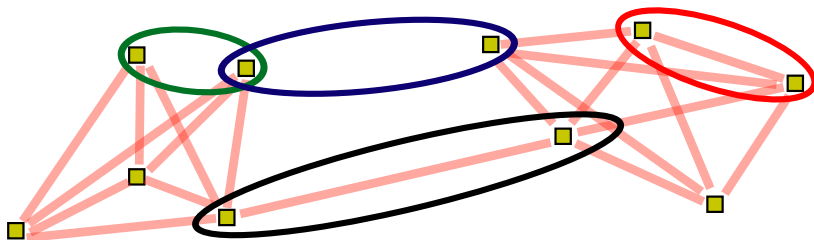




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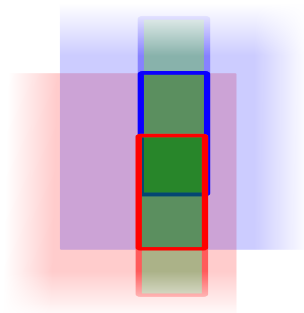
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# Self Mediated Agreement by Confluence

Negotiation:

- ▶  $(G_1, G_2) \rightarrow (G_1^{+G_2}, G_2^{+G_1})$
- ▶  $G_1^{+G_2}$ : **add** synonyms of  $G_2$  that are *potential synonyms* of  $G_1$
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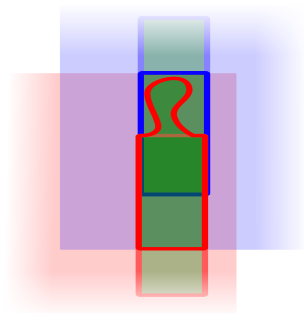
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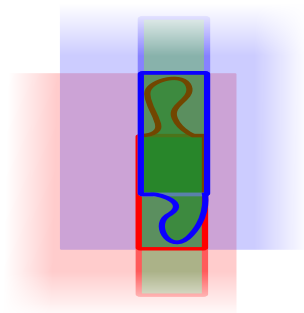
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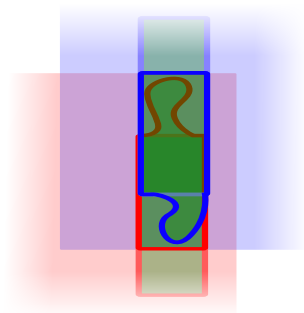
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# Experimental set up

- ▶ Negotiation between pairs of graphs (same POS, same language),
- ▶ Shortest “interesting” walks:  $t = 2$ ,
- ▶ Measure Kappa of graphs after negotiation,
- ▶ Control experiment: negotiation of *random graphs* (same edge agreement).

# Results

	$K_{\uparrow}$	$Ben_V$	$Ber_V$	$Lar_V$	$Rob_V$	$Wik_V$
$Bai_V$	ori.	0.583	0.309	0.255	0.288	
	acc.	<b>0.777</b>	<b>0.572</b>	<b>0.603</b>	<b>0.567</b>	
	ori. r.	0.583	0.309	0.256	0.288	
$Ben_V$	acc. r.	0.585	0.313	0.262	0.293	
	ori.		0.389	0.276	0.293	
	acc.		<b>0.657</b>	<b>0.689</b>	<b>0.636</b>	
$Ber_V$	ori. r.		0.390	0.276	0.294	
	acc. r.		0.392	0.283	0.301	
	ori.			0.416	0.538	
$Lar_V$	acc.			<b>0.838</b>	<b>0.868</b>	
	ori. r.			0.417	0.539	
	acc. r.			0.434	0.549	
$PWN_V$	ori.				0.518	
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- From medium to strong agreement,
- From weak to medium agreement,
- Control: random networks fail to improve.
- Note: order is not maintained !



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$PWN_V$	acc.			<b>0.838</b>	<b>0.868</b>	
	ori. r.			0.417	0.539	
				0.434	0.549	
					0.518	
					<b>0.852</b>	
					0.518	
					0.529	
						0.247
	acc.					<b>0.540</b>
	ori. r.					0.247
	acc. r.					0.251

- From medium to strong agreement,
- From weak to medium agreement,
- Control: random networks fail to improve.
- Note: order is not maintained !

# Results

	$K_{\downarrow}$	$Ben_V$	$Ber_V$	$Lar_V$	$Rob_V$	$Wik_V$
$Bai_V$	ori.	0.583	0.309	0.255	0.288	
	acc.	<b>0.777</b>	<b>0.572</b>	<b>0.603</b>	<b>0.567</b>	
	ori. r.	0.583	0.309	0.256	0.288	
	acc. r.	0.585	0.313	0.262	0.293	
$Ben_V$	ori.		0.389	0.276	0.293	
	acc.		<b>0.657</b>	<b>0.689</b>	<b>0.636</b>	
	ori. r.		0.390	0.276	0.294	
	acc. r.		0.392	0.283	0.301	
$Ber_V$	ori.			0.416	0.538	
	acc.			<b>0.838</b>	<b>0.868</b>	
	ori. r.			0.417	0.539	
				0.434	0.549	
					0.518	
					<b>0.852</b>	
					0.518	
					0.529	
						0.247
						<b>0.540</b>
$PWN_V$	acc.					
	ori. r.					0.247
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						0.247
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$PWN_V$	acc.					0.247
	ori. r.					0.247
	acc. r.					0.251

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# Conclusions and Perspectives

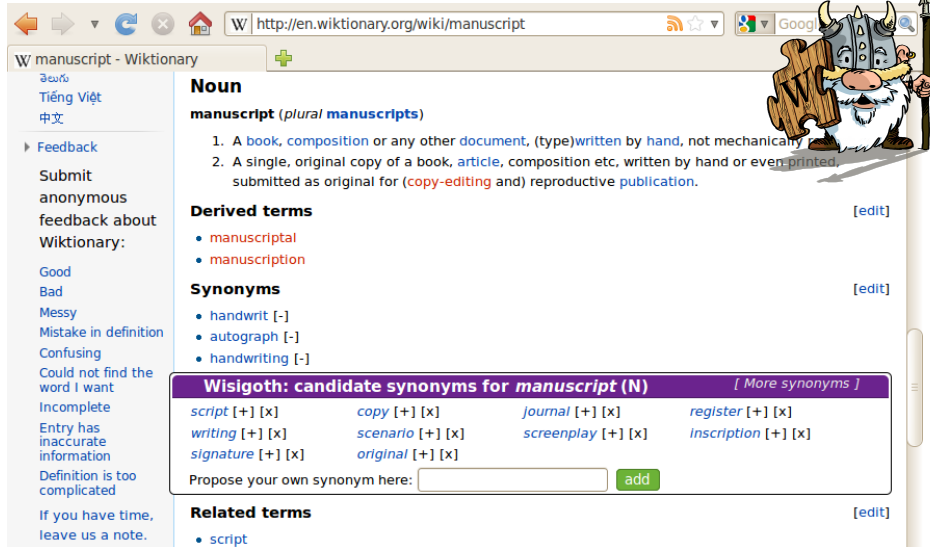
## Global agreement on semantic structures of resource despite pair by pair synonymy variability:

- ▶ Semantic disagreement between structurally different resources

## Perspectives and applications:

- ▶ **Merging** resources:  
between union and intersection, filtering shortcuts,
- ▶ **Evaluating** resources:  
Semantic agreement of new resources with (sets of) established resources,
- ▶ **Bilingual** semantic comparison:  
via translation bigraph, SMAC of graphs of different languages,
- ▶ Semi-automatic **enrichment** of Wiktionary by confluence.

# Application to semi-automatic enrichment of Wiktionary



The screenshot shows a web browser window displaying the Wiktionary page for the word "manuscript". The browser's address bar shows the URL "http://en.wiktionary.org/wiki/manuscript". The page title is "manuscript - Wiktionary". On the left side, there is a sidebar with navigation links: "Tiếng Việt", "中文", "Feedback", "Submit", "anonymous", "feedback about Wiktionary:", "Good", "Bad", "Messy", "Mistake in definition", "Confusing", "Could not find the word I want", "Incomplete", "Entry has inaccurate information", "Definition is too complicated", and "If you have time, leave us a note." The main content area is titled "Noun" and defines "manuscript" (plural "manuscripts") as: 1. A book, composition or any other document, (type) written by hand, not mechanically. 2. A single, original copy of a book, article, composition etc, written by hand or even printed, submitted as original for (copy-editing and) reproductive publication. Below the definition are sections for "Derived terms" (manuscriptal, manuscription) and "Synonyms" (handwrit [-], autograph [-], handwriting [-]). A purple box titled "Wisigoth: candidate synonyms for manuscript (N)" contains a table of candidate synonyms with their frequency counts. To the right of the table is a link "[ More synonyms ]". Below the table is a form to "Propose your own synonym here:" with an "add" button. At the bottom right, there is a link "[edit]". A cartoon character of a bearded man with a crown and a large letter W on his chest is standing on the right side of the page.

W manuscript - Wiktionary

**Noun**

**manuscript** (plural **manuscripts**)

1. A book, composition or any other document, (type) written by hand, not mechanically.
2. A single, original copy of a book, article, composition etc, written by hand or even printed, submitted as original for (copy-editing and) reproductive publication.

**Derived terms** [\[edit\]](#)

- manuscriptal
- manuscription

**Synonyms** [\[edit\]](#)

- handwrit [-]
- autograph [-]
- handwriting [-]

**Wisigoth: candidate synonyms for manuscript (N)** [\[ More synonyms \]](#)

<i>script</i> <a href="#">[+]</a> <a href="#">[x]</a>	<i>copy</i> <a href="#">[+]</a> <a href="#">[x]</a>	<i>journal</i> <a href="#">[+]</a> <a href="#">[x]</a>	<i>register</i> <a href="#">[+]</a> <a href="#">[x]</a>
<i>writing</i> <a href="#">[+]</a> <a href="#">[x]</a>	<i>scenario</i> <a href="#">[+]</a> <a href="#">[x]</a>	<i>screenplay</i> <a href="#">[+]</a> <a href="#">[x]</a>	<i>inscription</i> <a href="#">[+]</a> <a href="#">[x]</a>
<i>signature</i> <a href="#">[+]</a> <a href="#">[x]</a>	<i>original</i> <a href="#">[+]</a> <a href="#">[x]</a>		

Propose your own synonym here:  [add](#)

**Related terms** [\[edit\]](#)

- script

WISIGOTH Project : <http://redac.univ-tlse2.fr/wisigoth/>

Thank you !

Any question?



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