NONPARAMETRIC STATISTICAL STRUCTURING OF KNOWLEDGE SYSTEMS USING BINARY FEATURE MATCHES

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ABSTRACT

Structuring knowledge systems with binary features is often based on imposing a similarity measure and clustering objects according to this similarity. Unfortunately, such analyses can be heavily influenced by the choice of similarity measure. Furthermore, it is unclear at which level clusters have statistical support and how this approach generalizes to the structuring and alignment of knowledge systems. We propose a non-parametric Bayesian generative model for structuring binary feature data that does not depend on a specific choice of similarity measure. We jointly model all combinations of binary matches and structure the data into groups at the level in which they have statistical support. The model naturally extends to structuring and aligning an arbitrary number of systems. We analyze three datasets on educational concepts and their features and demonstrate how the proposed model can both be used to structure each system separately or to jointly align two or more systems. The proposed method forms a promising new framework for the statistical modeling and alignment of structure across an arbitrary number of systems.

Index Terms— Bayesian non-parametrics, relational modeling, binary similarity, knowledge structuring.

1. INTRODUCTION

The representation, structuring, and alignment of domain knowledge is an important challenge within computer science, information science, cognitive science, computational linguistics and philosophy. Knowledge representation and alignment is needed for diverse applications such as the alignment of library classification systems [1], biomedical ontologies [2], and industry specific taxonomies [3]. In this work, we study the case where objects are represented by a number of binary features.

The structuring of knowledge within or across systems often relies on the computation of similarities between objects [4, 1, 2, 5]. One of the traditional approaches for computing similarities is the common extension comparison between two objects [4]. Let f_{xy} denote the number of features where object X takes the value $x \in$ $\{0, 1\}$ and object Y takes the value $y \in \{0, 1\}$. A multitude of similarity measures have been employed for knowledge alignment based on different variations of quantifying similarity using these matches including the Jaccard index [6], Simple Matching Coefficient (SMC), and Tversky's Ratio Model [7] that respectively are



Fig. 1: Examples of similarity computation between features of two domains in which Jaccard (top) and SMC (bottom) fail in identifying the underlying (two) groups of objects in both domains despite the clear structures present in each of the different type of matches. By exploiting the structure of all types of matches (i.e., 0-0, 0-1, 1-0 and 1-1) the proposed framework for structuring binary similarity in both cases correctly identifies the existence of two groups in each system.

given by

$$Jaccard(X,Y) = f_{11}/(f_{11} + f_{10} + f_{01}),$$

$$SMC(X,Y) = (f_{11} + f_{00})/(f_{11} + f_{10} + f_{01} + f_{00}),$$

$$Tversky(X,Y) = f_{11}/(f_{11} + vf_{10} + \beta f_{01}).$$

In Tversky's Ratio Model, v and β are used to define the relative influence of 1–0 and 0–1 matches such that for $v = \beta = 1$ Tversky's Ratio Model is equivalent to the Jaccard similarity. Unfortunately, the alignment of knowledge systems can be strongly affected by the similarity measure employed. Consider for instance the two examples given in Figure 1 in which the Jaccard index and SMC each are unable to detect structure between two groups of entities in two systems despite the clear structure in the raw f_{xy} matches.

Similarity computations between objects play important roles in the ontology alignment discipline, integrated with the structural information of ontologies. For example, performances of aligning industry specific taxonomies and regulations employing a similarity measure (i.e. cosine similarity, Jaccard similarity, or market basket analysis) combined with hierarchical structure information were compared in [3]. Performances of biomedical ontology mapping with a new ontological similarity measure, named Tversky's parameterized ratio model of similarity were investigated in [2] and compared against other measures derived from the idea of Tversky's Ratio model [8, 9]. While the performance evaluation of ontology matching is one branch of knowledge alignment, performance of similarity-based alignment and (re-)structuring of two knowledge systems was investigated in [10].

When structuring systems based on similarity an important open problem is to quantify the number of groups which are significant: Similarities based on few features are inherently more uncertain compared to similarity measures defined using many features. Consequently an alignment approach should take this uncertainty into account. We presently propose a non-parametric Bayesian generative model for the structuring of binary data that is not reduced to a specific projection of the different f_{xy} matches based on existing similarity measures such as Jaccard, SMC or Tversky's Ratio Model but exploits the entire structure of all matches simultaneously when structuring and aligning systems. The method can be used to simultaneously align an arbitrary number of systems and is able to automatically infer the number of groups within each system by quantifying the level in which groups have statistical support as defined by their structured interactions across the considered matches. The model proposed extends the existing block-modeling frameworks [11, 12, 13, 14] to the modeling of binary similarity matches and we demonstrate the models utility for the alignment of concepts within and between three educational systems.

2. MODEL FOR BINARY FEATURE MATCHES

We consider organizing knowledge both within and between systems. Let $f_c(i, j)$ be the number of matches between observation i and j of type $c \in C$. For example, for binary data between two systems we have $C = \{(00), (01), (10), (11)\}$. Let $\mathbf{f}(i, j)$ denote the vector of match counts for all types, and let \mathcal{F} denote the counts for all types and pairs of objects. Let further $N_{i,j} = \sum_c f_c(i, j)$ denote the total number of binary features.

A single system: We will initially consider structuring binary data from a single system such that $f_c(i,j) = \sum_n \delta[x_{in}, c(1)] \delta[x_{jn}, c(2)]$ where x_{in} denotes the *n*th feature of the *i*th object. As prior distribution for the clustering of objects to groups, z, we will use the Chinese Restaurant Process (CRP) which defines a probability distribution over a partitioning of a set of objects. The CRP is parameterized by a concentration parameter α which governs its propensity to forming new groups (see also [15, 16]). Once the partitioning is formed we model the relative probability of observing each of the different types of matches between groups a and b, denoted $\eta(a, b)$, by a Dirichlet prior. The prior is parameterized by η_0 that specifies the relative extend to which the different types of matches occur. Finally, we model the vector of the number of matches of all types between object i and j, f(i, j), by a multinomial distribution parameterized by $\eta(z_i, z_j)$ (where z_i denotes the group to which observation i is assigned) as well as the total number of features in the similarity computation N(i, j). Thus, our generative model for organizing knowledge within one system based on all (four) types of binary similarity matches is given by

$\mathbf{z} \sim \operatorname{CRP}(\alpha),$	objects to groups,
$\boldsymbol{\eta}(a,b) \sim \mathrm{Dirichlet}(\boldsymbol{\eta}_0),$	proportion of types,
$\mathbf{f}(i,j) \sim \operatorname{Mult}(\boldsymbol{\eta}(z_i, z_j), N(i, j)),$	no. of matches of each type.

From the above generative model of \mathcal{F} the joint distribution can be derived and since the Dirichlet distribution is conjugate to the multinomial distribution $\eta(a, b)$ can be analytically marginalized,

$$\begin{split} p(\boldsymbol{\mathcal{F}},\mathbf{z}|\alpha,\boldsymbol{\eta}_{0}) &= \int \prod_{i\neq j} p(\mathbf{f}(i,j)|\mathbf{z},\boldsymbol{\eta}) p(\boldsymbol{\eta}|\boldsymbol{\eta}_{0}) p(\mathbf{z}|\alpha) d\boldsymbol{\eta} = \\ & \left[\prod_{i\neq j} \frac{N(i,j)!}{\prod_{c} f_{c}(i,j)!} \prod_{a,b} \frac{\mathbf{B}(\mathbf{m}(a,b))}{\mathbf{B}(\boldsymbol{\eta}_{0})} \right] \cdot \frac{\Gamma(\alpha) \alpha^{K}}{\Gamma(\alpha+I)} \prod_{k} \Gamma(n_{k}), \end{split}$$

where n_k is the number of objects in group k, I is the total number of objects, $\boldsymbol{m}(a, b) = \sum_{i \neq j} \boldsymbol{f}(i, j)\delta(z_i, a)\delta(z_j, b)$ is the number of matches between groups a and b, and $B(\boldsymbol{\gamma}) = \frac{\prod_a \Gamma(\gamma_a)}{\Gamma(\sum_a \gamma_a)}$ is the multinomial Beta function.

Multiple systems: For structuring knowledge across multiple systems we extend the above model to consider all 2^D types of binary matches where $D \ge 2$ is the number of systems. For example, for three systems we have $C = \{(000), (001), \ldots, (111)\}$. We introduce system specific groups such that the observed matches of type c are given by the D'th order tensor \mathcal{F}_c with elements $f_c(i_1, \ldots, i_D)$,

$$\mathbf{z}^{(d)} \sim \operatorname{CRP}(\alpha_d), \quad \text{for } d \in \{1, \dots, D\},$$

$$\boldsymbol{\eta}(a_1, \dots, a_D) \sim \operatorname{Dirichlet}(\boldsymbol{\eta}_0),$$

$$\mathbf{f}(i_1, \dots, i_D) \sim \operatorname{Mult}(\boldsymbol{\eta}(z_{i_1}^{(1)}, \dots, z_{i_D}^{(D)}), N(i_1, \dots, i_D)).$$

We thereby obtain the following joint distribution

1

$$p(\boldsymbol{\mathcal{F}}, \mathbf{z} | \boldsymbol{\alpha}, \boldsymbol{\eta}_{0}) = \prod_{i_{1}, \dots, i_{D}} \frac{N(i_{1}, \dots, i_{D})!}{\prod_{c} f_{c}(i_{1}, \dots, i_{D})!}$$
$$\prod_{a_{1}, \dots, a_{D}} \frac{B(\mathbf{m}(a_{1}, \dots, a_{D}))}{B(\boldsymbol{\eta}_{0})} \cdot \prod_{d} \frac{\Gamma(\alpha_{d})\alpha_{d}^{K_{d}}}{\Gamma(\alpha_{d} + I_{d})} \prod_{k_{d}} \Gamma(n_{k_{d}}),$$

where the notation is similar to that in the one system model. When D = 2 the model reduces to co-clustering the four types of binary matches between two systems.

According to the above model for structuring single and multiple systems, objects are structured according to their interactions across groups constituting homogenous blocks of binary match counts. The above framework is thereby closely related to stochastic block models [11, 12] and non-parametric extensions such as the infinite relational model [13, 14]. Thus, the proposed model can be considered an extension of the existing block-modeling frameworks to multinomial distributed count statistics.

Model inference: In order to infer z we use Markov chain Monte Carlo (MCMC) based on Gibbs sampling with split-merge moves [17, 18]. When modeling D systems, the Gibbs sampler cycles through the observations of each of the D systems one at a time and the split-merge sampler proposes merge or split moves within each system. The hyper-parameters η_0 and α are inferred by imposing an improper uniform prior, transforming the variable to the log-domain, and using a Metropolis-Hastings random walk procedure based on a normal proposal distribution with standard deviation 0.1. In our experiments the sampler was run for 1000 iterations where each iteration constituted a Gibbs sweep and 10 split-merge moves for inferring z within each system, 100 randomwalk moves for each α_d parameter, and 10 random walk moves for each parameter in η_0 .

Table 1: Mean normalized mutual information (NMI) between runs as well as mean number of extracted components (K). In parenthesis is given the uncertainty on the least significant digit computed as the standard deviation of the mean across the 10 runs.

	System 1		Syst	em 2	System 3		
	NMI	K	NMI	K	NMI	K	
Korea	1.00(0)	11.0(0)	-	-			
Czech	0.97(1)	10.0(0)	-	-			
Japan	0.95(2)	12.5(2)	-	-			
Korea-Czech	1.00(0)	6.0(0)	0.97(1)	15.4(2)	-		
Korea-Japan	0.99(1)	9.2(1)	0.94(2)	13.8(1)	-		
Czech-Japan	0.94(1)	11.6(2)	0.85(4)	6.0(0)	-		
KorCzJap.	1.00(0)	10.0(0)	0.99(0)	24.4(2)	1.0(0)	21.0(0)	

3. ALIGNMENT OF UNESCO EDUCATIONAL SYSTEMS

To demonstrate and evaluate our proposed model, we analyze a UN-ESCO dataset of educational systems.

Data: The datasets employed represents educational systems of Republic of Korea (Korea), Czech Republic (Czech), and Japan, which are available from the UNESCO Institute of Statistics (UIS) website¹. The datasets consist of 55, 60 and 54 educational concepts respectively in Korea, Czech and Japan, and their 127 standardized features pre-defined by UIS in accordance with International Standard Classification of Education (ISCED). Fig. 2.a overviews distributions of educational concepts (K1-K55, C1-C60, J1-J54) in the six ISCED levels starting from pre-primary to tertiary education. Features other than the ISCED levels are for example program orientations, entrance requirements, starting age, cumulative duration, qualifications etc. Some of these features can be seen in the "shared features" columns of Fig. 2.b. Based on these data we create binary concept-features matrices for the three systems.

Results: We analyzed each system separately, two systems at a time, and all three systems jointly. In our analysis we ran the sampler ten times initialized differently both in terms of initial number of components and the order in which the modes were updated. We extracted from each run the sample with highest value of the joint-distribution and evaluated the number of components as well as normalized mutual information (NMI) between the ten runs. A NMI of 1 would indicate perfect correspondences between the extracted groups across runs. These results are given in Table 1. From the table it can be seen that the highest likelihood solution was very reliably identified when analyzing all three systems jointly as well as Korea separately with NMI all above 0.99 whereas the structure inferred when analyzing Czech and Japan jointly was the least stable with NMI of 0.94 and 0.85 for the two systems respectively.

In the following we display representative results obtained using a single run. Fig. 3.a illustrates the single system modeling (i.e., unipartite clustering) of the three educational systems. The graphs overview the statistically extracted structures in all types of binary matches for each single system and especially demonstrate that the Korean system has clear structure with relatively uniform clusters. The similar phenomenon is observable from the results of the Japanese system although the structures are slightly blurred compared to the Korean structures. Fig. 3.a reveals that more features

		_		ISCEI	0 ISCED 1	ISCED 2	2 ISCED 3	ISCED	4 ISCED 5	ISCE	D6	NC
2-	a: Educational concep	ots				Lower	Linner	Post-	Tertiary	Tertie	arv	
an	id their ISCED levels			Pre-prin	ary Primary	secondary	y secondary	seconda	ry, (1. stage)	(2. sta	18C)	
				12.1	10.0			Non-terta	eary Kal co	NO.		
			Korea	KI-	C4.0	K0+10	K11-20	(720.7	K21-50	K51-	-50	660.60
			Czech	CI	5 04-8	09-18	C19-29	120-2	4 136.40	100	.9	0.50+60
			Japan	115	J4-5	30+8	19+29	130+3	4 335-49	120-	-52	J53+54
lust	Korean	clusters		Clust	C	zech clust	ers	Clust	1	apanese	clusters	
ID	11 clusters	shar	ed features	er ID	10 clusters		shared features	er ID	12 clusters	s	shar	ed features
	K26, K28, K29, K30,				C9, C12, C14, C15,	C16, ac	dults:N, part-time:?	٩,		120, 122	ISCED3,	duration:3, sta
	K31, K32, K33, K34,	Bache	IOF, ISCEDS,	CUI	C17, C18, C19, C20,	C27, cer	rtification (ISCED2	2/3, JU1	125 126 12	120, 322,	age:1	5, require:2,
	K39, K40, K41, K48,	dura	tion:16 etc	ne -	C38		orientation:G/P)		525, 520, 52	.0	cumulat	ive duration:12
	K50						adults: Y/N, part-			6.116	ISCED:	3, duration:3+,
		ISCEL	3, require:2,	cura	C21, C23, C24, C25,	C28, tir	me: Y/N, certification	on JU2	110, 111, 113, 113	5, 110,	start age	e:15, require:2,
U2	K35, K36, K37, K43,	cumulati	ve duration: I	2, CU2	C29, C31, C32, C34,	, C36	(ISCED3/4,		319, 321, 32		cumulati	ve duration:12-
	K44, K45, K40, K47	startin	ng age:15 etc.				orientation:G/V/P)		J38, J41, J42, J47	7, J48,	ISCED5.	, adults:N, part
		Maste	rr ISCED5			ce	ertification. adults:1	JU3	J49			time:N
	K15, K16, K17, K18,	require:	5A(1st), cun	CU3	C1, C2, C3, C4, C5,	, C6,	part-time:N (start				ISCED	4, duration:1+,
U3	K19, K20	du	ration:18,		C7, C8, C50, C5	age age	:3/6/15, ISCED0/1	/N) JU4	130, 131, 132, 13	i3, J34	sta	art age: 18
		orien	tation:G etc.		C52, C55, C56, C58,	C59,		JU5	J35, J37, J44, J4	15, J46	I	ISCED5
		PhD	ISCED6.	- CU4	C60		part-time				ISCED3	, destination:C
U4	K51, K52, K53, K54,	requi	ire:5A(2nd)		C33. C39. C40. C41.	C43.	adults: Y/N. part-	106	J17, J24, J27,	J29	orient	tation:V etc.
	K55	cumulati	ve duration:2	1+ CU5	C45	tin	me: Y/N (ISCED4/	5)			E	SCED5.
		ISCE	D2 starting		C11. C13. C22. C26.	C30.	certification	JU7	J36, J39, J40,	J43	certific	ation/diploma
U5	K6, K7, K8, K9, K10	age:1	2, require:1,	CU6	C37		(ISCED2/3/4)	JU8	J1, J2, J3		ISCED	0. duration 1-3
		cumula	tive duration:	9			adults, part-time	-			I	SCED6.
		Marte	r ISCEDS	- CU7	C35, C46, C48, C4	49	(ISCED4/5/6)	JU9	J50, J51, J5	2	requi	ire:5A(2nd)
		require:	5A(1st), cun			IS	CED5, orientation:	Α.			ISCED2	destination:A
U6	K11, K12, K13, K14	du	ration:18,	CU8	C42, C44, C47		adults, part-time	JU10	J6, J7, J8		cumula	tive duration:9
		orien	tation:V etc.	CU9	C53, C54, C57		certification				ISCED	1. cumulative
		Asso	ciate degree	-		IS	CED2. destination:	C. JUII	J4, J5		dı	uration:6
U7	K22, K23, K24, K49	ISCED5	, destination:	B, CU10	C10		orientation:P	JU12	J53, J54		certificat	tion. duration.1
		cumulat	ive duration: l	4								
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-						2-b: U	Unipartite clus	tering a	ssignments			
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U9 U10 U11	K25, K27, K42 K1, K2 K21, K38	ISCED0 ISCED duca	SCED5), start age: 3 5, cumulativ ation: 14-15	5					- g			
U9 U10 U11	K25, K27, K42 K1, K2 K21, K38	ISCED0 ISCED duca	SCED5), start age: 3 5, cumulativ ttion: 14-15	5	Cz	ech (x Jap	pan)			Korean (x	: Japan)	
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U9 U10 U11	K25, K27, K42 K1, K2 K21, K38 Korcan (6 (x 16) clusters K1, K2, K22, K23, K24, K25, K26, K27, K28, K29, K30, K31, K42, K33, K34, K35, K36, K37, K39, K40, K61, K40, K40, K40, K61	I ISCEDO ISCED duca x Czech) Unipar Merger KU7,	SCED5 h, start age: 3 5, cumulativition: 14-15 rtite element: of KU1, KU2 KU9, KU10	5	Czz 12 (x 6) clusters C9, C12, C14, C15, C17, C18, C19, C20, C30, C37, C38 C11, C13, C21, C25, C29, C36 C40, C42, C43, C44,	ech (x Jap s U C16, C27, C .C28, .C45, C	pan) Juipartite element UI and part of CU part of CU6, CU2 U8 and part of CU	s 6 5,	k 9 (x 14) clust (x 25, k26, k27, k29, k30, k31, k33, k34, k39, k41, k42, k48 K11, k12, k13, k15, k16, k17,	Xorean (x ters , K28, , K32, , K40, , K50 , K14, , K18,	Japan) Unipar Merger Merger	rtite elements • of KU1, KU9 • of KU3, KU6
U9 U10 U11	K25, K27, K42 K1, K2 K21, K38 Korean (6 (x 16) clusters K1, K2, K22, K23, K24, K25, K26, K27, K28, K29, K30, K31, K32, K33, K34, K35, K36, K37, K39, K40, K41, K42, K43, K44, K45, K46, K47, K48, K49, K50	I ISCED0 ISCED duca x Czech) Unipar Merger KU7,	SCED5), start age: 3 5, cumulativition: 14-15 rtite element of KU1, KU2 KU9, KU10	5	Czz 12 (x 6) cluster C9, C12, C14, C15, C17, C18, C19, C20, C30, C37, C38 C11, C13, C21, C25, C29, C36 C40, C42, C43, C44, C47, C48	ech (x Jap s U C16, C27, C C28, C45, C	pan) Unipartite element UI and part of CU part of CU6, CU2 U8 and part of CU CU7	s 6	k 9 (x 14) clust K25, K26, K27, K39, K30, K31, K33, K34, K39, K41, K42, K48, K11, K12, K13, K15, K16, K17, K19, K20	Korean (x ters , K28, , K32, , K40, , K50 , K14, , K18,	Japan) Unipar Merger Merger	rtite elements • of KU1, KU9 • of KU3, KU6
U9 U10	K25, K27, K42 K1, K2 K21, K38 Korean (6 (x 16) clusters K1, K2, K22, K23, K24, K25, K26, K27, K28, K33, K34, K35, K36, K37, K39, K40, K41, K42, K43, K44, K45, K36, K11, K12, K13, K14,	I ISCED0 ISCED duca x Czech) Unipar Merger KU7,	SCED5), start age: 3 5, cumulative tition: 14-15 rtite element of KU1, KU2 KU9, KU10	5	Cra 12 (x 6) claster C9, C12, C14, C15, C17, C18, C19, C20, C30, C37, C18 C11, C13, C21, C25, C29, C36 C40, C42, C43, C44, C47, C48 C4, C5, C6, C7, C8,	ech (x Jap s U C16, C27, C C28, C28, C45, C C51	pan) Inipartite element UI and part of CU part of CU6, CU2 U8 and part of CU CU7 part of CU3	s 6	k 9 (x 14) clust K25, K26, K27, K33, K34, K39, K41, K42, K48, K11, K12, K13, K15, K16, K17, K19, K20 K35, K36, K37,	Corean (x ters , K28, , K32, , K40, , K50 , K14, , K18, , K43,	Japan) Unipar Merger Merger	ritic clements • of KU1, KU9 • of KU3, KU6 KU2
U9 U10 U11	K25, K27, K42 K1, K2 K21, K38 K6 (x 16) clusters K1, K2, K22, K23, K24 K25, K26, K27, K28, K29, K30, K31, K32, K33, K34, K35, K36, K37, K39, K40, K41, K42, K43, K44, K45, K46, K47, K48, K49, K50 K11, K12, K13, K14,	I ISCED0 ISCED duca x Czech) Unipar Merger KU7, Merger	SCED5), start age: 3 S, cumulativ tition: 14-15 rtite element of KU1, KU2 KU9, KU10 · of KU3, KU	5	Czx 12 (x 6) clustern C9, C12, C14, C15, C17, C18, C19, C20, C30, C37, C38 C11, C13, C21, C25, C29, C36 C40, C42, C43, C44, C47, C48 C4, C5, C6, C78, C8, C4, C5, C6, C58, C8,	ech (x Jap s U C16, C27, C C28, C45, C C51 C59,	pan) Inipartite element UI and part of CU part of CU6, CU2 U8 and part of CU CU7 part of CU3 CI14	s 6	k 9 (x 14) clust K25, K26, K27, K29, K30, K31, K33, K34, K39, K41, K42, K43, K11, K12, K13, K15, K16, K17, K19, K20, K35, K36, K20, K44, K45, K46,	Corean (x kers , K28, , K32, , K40, , K40, , K43, , K43, , K43,	Japan) Unipar Merger Merger	rtite elements • of KU1, KU9 • of KU3, KU6 KU2
U9 U10 U11	K25, K27, K42 K1, K2 K1, K3 6 (x 16) clusters K1, K2, K22, K23, K24, K25, K26, K27, K28, K33, K34, K45, K56 K37, K39, K60, K47, K38, K42, K43, K44, K55 K66, K47, K48, K49, K50 K11, K12, K13, K14, K15, K10, K17, K10	I ISCED0 ISCED duca x Czech) Unipar Merger KU7, Merger	SCED5 1, start age: 3 5, cumulative stion: 14-15 ritic elements of KU1, KU2 KU9, KU10 · of KU3, KU3	5	Cz 12 (x 6) claster C9, C12, C14, C15, C17, C18, C19, C20, C30, C37, C38 C11, C13, C21, C25, C29, C36 C40, C42, C43, C44, C47, C48 C4, C5, C6, C7, C8, C52, C55, C56, C58, C60	ech (x Jap s U C16, C27, C C28, C45, C C51 C59,	pan) Unipartite element UI and part of CU part of CU6, CU2 U8 and part of CU CU7 part of CU3 CU4	s 6	K 9 (x 14) clust R25, K26, K27, K29, K30, K31, K33, K34, K39, K41, K42, K48, K11, K12, K13, K15, K16, K17, K19, K20, K35, K36, K37, K44, K45, K46, K51, K52, K53, K	Corean (x kers , K28, , K32, , K40, , K40, , K40, , K14, , K18, , K43, , K47 , 54, K55	Japan) Unipar Merger Merger	rtite elements • of KU1, KU9 • of KU3, KU6 KU2 KU4
U9 U10 U11	K25, K27, K42 K1, K2 K21, K38 6 (x. 16) clusters K1, K2, K22, K23, K43 K25, K26, K72, K28, K42 K28, K43, K43, K53, K44, K55 K49, K40, K41, K43, K44, K55 K40, K47, K48, K49, K50 K11, K22, K43, K44, K55 K61, K17, K18, K49, K50 K11, K22, K43, K44, K55 K61, K17, K18, K49, K50 K61, K17, K18, K49, K10	I ISCED0 ISCED duca x Czech) Unipar Merger KU7, Merger	SCED5), start age: 3 , start age: 3 , cumulative start age: 3 cumulative start age: 3 cumulative start age: 3 cumulative the cumulative start age: 3 cumulative start age: 3 cumulative	5	Czz 12 (x 6) clasters C9, C12, C14, C15, C17, C18, C19, C20, C30, C37, C38 C11, C13, C21, C25, C29, C36 C40, C42, C43, C44, C47, C48 C4, C5, C6, C7, C8, C52, C55, C56, C58, C60 C31, C32, C34, C39, C40, C42, C43, C49, C60 C31, C32, C34, C39, C40, C42, C43, C59, C60 C31, C32, C34, C39, C40, C42, C43, C59, C40, C42, C43, C40, C42, C40, C4	ech (x Jap s U C16, C27, C C28, C45, C C51 C59, C41 pi	pan) Ulipartite element 201 and part of CU part of CU6, CU2 U8 and part of CU CU7 part of CU3 CU4 art of CU2 and CU	s 6 5, 5	K 9 (x 14) clust K25, K26, K27, K29, K30, K31, K33, K34, K39, K41, K42, K48 K11, K12, K13, K15, K16, K17, K19, K20 K35, K36, K37, K44, K45, K46 K51, K52, K53, K K6, K7, K8, K9	Corean (x ters , K28, , K32, , K40, , K14, , K14, , K14, , K43, , K43, , K43, , K47 (54, K55), K10	Japan) Unipas Merger Merger	ritic elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5
U9 U10 U11	K25, K27, K42 K1, K2 K21, K38 K21, K38 K21, K38 K21, K22, K22, K24, K28, K27, K28 K29, K30, K1, K22, K31, K42, K41, K42, K43, K44, K45, K41, K45, K41, K45, K41, K41, K45, K41, K45, K47, K48, K49, K50 K11, K12, K33, K44, K55 K14, K21, K33, K44, K55 K14, K21, K33, K43, K55 K51, K22, K33, K43, K55	I ISCED0 ISCED duca x Czech) Unipar Merger KU7, Merger	SCED5 1, start age: 3 5, cumulative for the elements of KU1, KU2 KU9, KU10 vof KU3, KU4 KU5 KU4	5	Cra 12 (x 6) clusters C9, C12, C14, C15, C17, C18, C19, C20, C30, C37, C28 C41, C13, C21, C25, C29, C36 C42, C42, C43, C44, C47, C48 C4, C5, C6, C7, C8, C60 C31, C32, C34, C39, C1, C2, C3, C50 C1, C13, C13, C12 C1, C13, C12, C25 C10, C12, C14, C13 C10, C12, C14, C14 C10, C14, C14 C10, C14, C14 C10, C14, C14 C10, C14, C14 C10, C14 C14 C14 C14 C14 C14 C14 C14	ech (x Jap s U C16, C27, C C28, C45, C C51 C59, C41 pi	pan) Jnipartite element 201 and part of CU part of CU6, CU2 US and part of CU CU7 part of CU3 part of CU3 att of CU2 and CU part of CU3	x 6 5,	k 9 (x 14) clast K25, K26, K27, K29, K30, K31, K33, K34, K39, K41, K42, K48, K11, K12, K13, K15, K16, K17, K19, K20, K35, K36, K37, K44, K45, K46, K51, K52, K53, K K6, K7, K8, K90, K22, K23, K24,	Xorean (x ters , K28, , K32, , K40, , K14, , K14, , K18, , K43, , K43, , K47 , 54, K55 0, K10 , K49	Japan) Unipas Merger Merger	rtite elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7
U9 U10 U11	K25, K27, K42 K1, K2 K21, K38 Kercan (6 (x 16) clusters K1, K2, K22, K23, K43 K29, K30, K11, K32, K29, K30, K11, K32, K33, K43 K45, K40, K40, K47, K48, K40, K50 K11, K12, K15, K41, K45 K11, K12, K15, K41, K45 K11, K12, K15, K41, K45 K11, K12, K13, K41, K45 K11, K12, K13, K41, K50 K11, K12, K13, K41, K45 K11, K12, K13, K44, K45 K11, K12, K13, K45, K45, K45, K45, K45, K45, K45, K45	I ISCED0 ISCED duca x Czech) Unipar Merger KU7, Merger	SCED5 1, start age: 3 5, cumulative for cumulative tition: 14-15 of KU1, KU2 KU9, KU10 v of KU3, KU4 KU5 KU4 KU8	5	Cra 12 (c 6) cluster C9, C12, C14, C15, (C 17, C18, C19, C20, C10, C37, C18, C19, C20, C10, C37, C18, C19, C20, C10, C42, C43, C44, C47, C48, C42, C5, C6, C7, C8, C52, C55, C56, C59, C11, C2, C3, C54, C12, C23, C24, C19, C12, C23, C24, C19, C11, C24, C11, C24	ech (x Jap s t C16, C27, C C28, C45, C C51 C59, C41 pr 26 p	pan) Taipartite element CU1 and part of CU part of CU6, CU2 U3 and part of CU3 CU7 part of CU3 art of CU2 and CU part of CU2 and CU sart of CU2 and CU	s 6 5, 5 6	K 9 (x 14) clust K25, K26, K27, K33, K34, K39, K11, K12, K13, K11, K12, K13, K11, K12, K13, K15, K16, K17, K19, K20, K51, K52, K32, K51, K52, K33, K3, K3, K2 K6, K7, K8, K9 K2, K23, K24, K3, K4, K4	Corean (x ters , K28, , K32, , K40, , K43, , K43, , K43, , K43, , K43, , K43, , K43, , K40, , K10, , K43, , K43, , K43, , K43, , K44, , K46, ,	Japan) Unipar Merger Merger	rtite elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7 KU8
U9 U10 U11	K25, K27, K42 K1, K2 K21, K38 K21, K38 K21, K38 K21, K2, K22, K23, K34 K28, K22, K22, K23, K34, K35, K54 K37, K39, K60, K41, K42, K43, K46, K57 K17, K38, K49, K50 K11, K12, K13, K44, K55 K16, K47, K48, K49, K50 K11, K12, K13, K44, K55 K13, K32, K33, K44, K55 K13, K32, K33, K44, K55 K12, K23, K44, K45 K12, K28, K44, K55 K12, K28, K44, K55 K12, K28, K44, K55 K12, K28, K44, K55	I ISCED0 ISCED duca x Czech) Unipar Merger KU7, Merger	SCED5 1, start age: 3 5, cumulative for the element of KU1, KU2 KU9, KU10 of KU3, KU3 KU4 KU4 KU4 KU11	5	Cra 12 (x 6) claster C9, C12, C14, C15, C17, C18, C19, C20, C30, C37, C18 C11, C13, C21, C25, C140, C42, C43, C44, C47, C48 C4, C52, C55, C56, C58, C60 C1, C2, C3, C54, C59, C1, C2, C3, C54, C59, C13, C54, C57, C33, C54, C57, C54, C	ech (x Jap t C16, C27, C C28, C45, C C51 C59, C45, C C51 C59, C45, C C9, C C27, C	pan) Inipartite element UI and part of CU Part of CU6, CU2 UI8 and part of CU CU7 Part of CU3 CU4 art of CU2 and CU Part of CU3 art of CU2 and CU CU9	x 6 5, 6	k 9 (x 14) clust 125, 126, 127, 129, 130, 131, 135, 144, 142, 143, 145, 146, 147, 143, 145, 146, 147, 145, 146, 147, 145, 146, 147, 145, 146, 147, 145, 146, 147, 145, 146, 147, 145, 146, 147, 146, 147,	Korean (x ters , K28, , K30, , K40, , K14, , K18, , K43, , K43, , K43, , K455 0, K10 , K49 5	Japan) Unipar Merger Merger	rtite elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7 KU8 KU10
U9 U10 U11	K25, K27, K42 K1, K2 K21, K38 Kerzen (6 (x 16) classiers K1, K2, K22, K23, K34 K25, K26, K27, K24 K28, K26, K27, K24 K28, K26, K27, K24 K34, K35, K46 K46, K47, K48, K46, K50 K11, K12, K15, K44, K51 K12, K12, K51, K44, K51 K12, K28	I ISCED0 ISCED duca x Czech) Unipan Merger KU7, Merger Korea)	SCED5 , start age: 5, cumulativ tition: 14-15 of KU1, KU2 KU9, KU10 of KU3, KU4 KU5 KU4 KU8 KU11	<u>5</u> 5	Ca 24 (5) claster C17, C18, C19, C10, C13, C18, C19, C20, C10, C13, C13, C23, C11, C13, C21, C23, C11, C13, C21, C23, C40, C42, C43, C44, C47, C48, C40, C42, C43, C44, C47, C48, C60, C13, C12, C3, C34, C1, C2, C3, C54, C12, C23, C34, C2 C13, C32, C34, C2 C13, C32, C34, C2 C13, C32, C34, C2 C13, C32, C34, C2 C13, C34, C37, C46, C49	ech (x Jap s t C16, C27, C .C28, .C45, C .C59, .C41 pi .26 p .26 p	aan) 'inipartite dement UI and part of CU part of CU6, CU2 US and part of CU CU7 part of CU3 CU4 art of CU2 and CU part of CU3 set of CU2md CU CU9 part of CU5	s 6 5, 5 6 6	8 9 (x 14) clust (x 25, t26, x 27, x 29, t30, t31, x 31, t34, t34, t34, x 41, t42, t48, x 11, t 124, t34, x 13, t 14, t 14, t 14, x 14, t 24, t 24, x 14, t 24, t 24, t 14, t 14	Corean (x ters , K28, , K40, , K40, , K14, , K18, , K18, , K43, , K43, , K47 , S4, K55 , K10 , K49 5	Japan) Unipas Merger Merger	rtite elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7 KU8 KU10 KU11
010	K25, K27, K2 K1, K2 K21, K38 K421, K38 K424, K38 K424, K38 K425, K23, K24, K25 K25, K27, K28 K25, K27, K28 K27, K28, K28, K28 K27, K28, K28, K28 K21, K28	I ISCED0 ISCED0 duca x Czech) Unipar KU7, Merger KU7, Merger KU7,	SCED5 1, start age: 3 5, cumulative 5, cumulative tition: 14-15 ritite element of KU1, KU2 KU9, KU10 of KU3, KU KU5 KU4 KU3 KU1 ritite element ritite element	5	Cz 12 (x6) diaster C9, C12, C14, C15, C19, C18, C14, C15, C19, C18, C19, C20, C10, C13, C21, C25, C29, C36, C40, C42, C43, C44, C47, C48, C42, C45, C46, C49, C12, C23, C24, C19, C12, C23, C24, C19, C13, C23, C24, C29, C13, C23, C24, C29, C13, C23, C24, C29, C14, C49, C49, C13, C25, C55, C58, C31, C22, C33, C44, C19, C13, C25, C45, C29, C14, C49, C49, C13, C25, C45, C29, C14, C14, C149, C13, C25, C45, C29, C14, C149, C13, C15, C149, C14, C149,	cch (x Jap clip t C16,	pan) inipartite dement UI and part of CU part of CU6, CU2 UU and part of CU CU7 part of CU3 CU4 art of CU3 and CU part of CU3 CU9 part of CU3 CU9 CU9 part of CU3 CU9 CU9 CU9 Part of CU3 CU9 CU9 CU9 CU9 CU9 CU9 CU9 CU9	s 6 5, 6 7	8 9 (x 14) clust R25, R26, R27, R29, R30, R31, R35, R44, R49, R46, R41, R42, R46, R41, R42, R46, R51, R52, R53, R57, R54, R45, R46, R51, R52, R53, R57, R56, R57, R56, R56, R56, R56, R56, R56, R56, R56	Corean (x ters , K28, , K32, , K40, , K43, , K14, , K18, , K14, , K43, , K43, , K47 5 5 5	Unipasa Unipasa Merger Merger	rtite elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7 KU8 KU10 KU10
U9 U10 U11	K25, K27, K42 K1, K2 K21, K38 K64, K10 clusters K1, K2, K22, K24, K34 K25, K26, K27, K24, K25, K26, K27, K25, K33, K34, K35, K26, K34, K35, K26, K27, K46, K47, K48, K69, K50 K11, K12, K13, K48, K46, K47, K48, K69, K50 K11, K12, K13, K44, K46, K47, K48, K69, K50 K11, K12, K13, K44, K46, K27, K8, K9, K10 K31, K26, K31, K4, K5 K21, K38 K21, K38 K	I ISCEDO ISCEDO duca x Czech) Unipau Merger KU7, Merger Korea) Unipau part of	SCED5 i, start age: 3, c, cumulativition: 14-15 ritite element of KU1, KU2 KU9, KU10 · of KU3, KU KU5 KU4 KU5 KU4 KU1 ritite element ritite element	5	Cz 12 (x 6) claster C9, C12, C14, C15, C17, C18, C19, C00, C30, C37, C38 C11, C13, C21, C25, C39, C36 C40, C42, C3, C44, C47, C48 C4, C25, C5, C56, C58, C60 C31, C32, C34, C39, C1, C2, C3, C34, C4, C49 C22, C32, C34, C39, C1, C23, C34, C39, C1, C32, C34, C32, C1, C32,	ech (x Jap x U C16, C27, C C28, C45, C C51 C59, C41 pi b 26 p P	nam) Taipartite element Taipartite element part of CU5, CU2 US and part of CU2 part of CU3 part of CU3	s 6 5 6 7	No. No. 9 (x) 140 dunt R25, R26, R27, R27, R29, R27, R29, R29, R29, R29, R29, R29, R29, R29	Sorean (x ters) , K28, , K32, , K40, , , K50) , K14, , K18, , , K43, , K47 , , K43, , K47 , , K44, , K18, , , K44, , K18, , , K45 , K10, , K49 , , K49 , K10, , K49 , , K49 , K10, , K49 , , K49 , K10, , K	: Japan) Unipar Merger Merger <u>Korean</u>) Unipar	rtite elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7 KU8 KU10 KU11 title elements
U9 U10 U11	K25, K27, K2 K1, K2 K21, K38 K02, K23, K38 K1, K2, K23, K24, K38 K1, K2, K23, K24, K25, K23, K24, K25, K27, K28, K27, K24, K25, K27, K28, K28, K28, K28, K33, K24, K25, K24, K25, K33, K24, K25, K24, K25, K19, K20, K21, K24, K25, K19, K20, K21, K24, K25, K19, K20, K21, K24, K25, K19, K20, K21, K24, K25, K21, K21, K21, K24, K25, K21, K23, K24, K25, K21, K23, K24, K25, K21, K21, K21, K21, K21, K21, K24, K25, K21, K21, K21, K21, K21, K21, K21, K21,	ISCED0 ISCED duca x Czech) Unipar Merger KU7, Merger Korea) Unipar	SCEDS , start age: 3, 5, cumulative tition: 14-15 of KU1, KU2 KU9, KU10 of KU3, KU4 KU5 KU4 KU4 KU4 KU4 KU4 KU11 CU6 and CU2	<u>5</u> 2	Cox 12 (6) distert (7) (2) (2) (2) (2) (2) (7) (2) (2) (2) (7) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (3) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2)	ech (x Jap C16, U C27, C C28, C C45, C C51 C59, C C45, C C51 C59, C C45, C C51 C59, C C45, C C51 C59, C C45, C C C45, C C C C C C C C C C C C C C	pan) anjuritite element Ul and part of CU part of CU6, CU2 US and part of CU CU7 Part of CU3 CU4 art of CU2 and CU part of CU3 part of CU3 cu19 part of CU3 cu19	s 5, 6 6 7 7	8 9 (x 14) clust 8 (x 25, 126, 827, 128, 128, 128, 128, 128, 128, 128, 128,	Corean (x K28, K32, K32, K40, K51, K50, K14, K18, K17, K18, K47, K18, K57, K55, K10, K43, K55, K10, K49, K10, K49, K10, K10, K10, K10, K10, K10, K10, K10	: Japan) Unipan Merger Merger Korean) Unipan	rtite elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7 KU7 KU8 KU10 KU10 KU10 rtite elements
U9 U10 U11	K25, K27, K42 K1, K2 K21, K38 K64, K10 clusters K1, K2, K22, K24, K44 K25, K26, K27, K24, K25, K26, K27, K28, K28, K20, K17, K28, K29, K30, K17, K28, K29, K30, K41, K28, K20, K21, K28, K40, K50 K11, K12, K13, K48, K40, K50 K11, K12, K13, K44, K51, K14, K45, K51, K14, K14, K51, K14, K14, K51, K14, K14, K51, K14, K14, K14, K14, K14, K14, K14, K1	I ISCEDØ ISCEDØ ISCED duca x Czech) Unipan Merger KU7, Merger Korea part of	SCED5 , start age: 3 5, cumulativition: 14-15 critic element of KU1, KU2 KU9, KU10 · of KU3, KU KU5 KU4 KU1 · critic element CU6 and CU rt of CU1	5	Ca (3) (4) (4) (4) (4) (4) (4) (4) (4) (4) (4	ech (x Jap 1 C16, C27, C C28, C45, C C51, C59, C41, p 26, p P pan (x Czz x C x C x C x C x C x C x C x C	nam) Inipartite element UI and part of CU part of CU6, CU2 US and part of CU part of CU3 part of CU3 cU4 et at of CU2 and CU part of CU3 et of CU3 cU4 cU4 cU4 cU4 cU4 cU4 cU4 cU4 cU4 cU4	x 6 6 5 5 6 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7	9 (1:10 clms; 9 (1:10 clms; K25, K23, K27, K35, K23, K27, K41, K42, K48, K11, K12, K13, K15, K16, K17, K16, K24, K24, K15, K16, K17, K16, K24, K24, K3, K24, K21, K15, K16, K17, K16, K24, K24, K3, K24, K24, K3, K24, K24, K3, K24, K24, K21, K23, K24, K24, K21, K23, K24, K24, K24, K24, K24, K24, K24, K24	Korean (x kers , K28, , K32, , K40, , K40, , K43, , K43, , K43, , K44, , K43, , K44, , K43, , K49 5 5 6 1 1 1 4 1 1 4, 118, 2, 2, 25,	Japan) Unipaa Merger Merger <u>Korean</u>) Unipar majority	ritic elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7 KU8 KU10 KU10 KU10 KU11 ritic elements of JU2
U9 U10 U11	K25, K27, K2 K1, K2 K21, K38 K02, K38 K02, K23, K38 K1, K2, K22, K23, K24, K25, K25, K27, K24, K25, K25, K27, K24, K25, K25, K27, K24, K25, K25, K27, K24, K27, K29, K21, K24, K27, K29, K21, K24, K25, K27, K29, K24, K25, K27, K29, K24, K25, K27, K29, K24, K25, K27, K29, K24, K25, K19, K20, K31, K24, K25, K19, K20, K31, K44, K55, K19, K20, K31, K44, K55, K19, K20, K31, K44, K55, K21, K19, K20, K31, K22, K31, K44, K55, K21, K19, K21, K21, K21, K21, K31, K21, K21, K21, K31, K21, K21, K21, K21, K21, K31, K21, K21, K21, K21, K21, K21, K21, K31, K21, K21, K21, K21, K21, K21, K21, K2	I ISCEDU ISCED duca ISCED duca Variante Merger Ku7, Merger Variante Variant	SCED5 , start age: d, start age: d, start age: d, start age: ritite element of KU1, KU2 KU9, KU10 of KU3, KU KU5 KU4 KU4 KU8 KU11 ritite element CU6 and CU2 rt of CU1	5	C (C) (C) (C) (C) (C) (C) (C) (C) (C) (C	ech (x Jap s L C16, C27, C C28, C45, C C59, C41 p p p p p p p p p n (C42, C C S9, C41 p S C41, C S9, C41, C S1, C S	pan) injpartite clement jart of CU6, CU2 US and part of CU CU7 part of CU3 cU7 part of CU3 art of CU3 cU3 part of CU3 cU3 part of CU3 cU3 part of CU3 cU3 cU3 cU3 cU3 cU3 cU3 cU3 c	s 6 5 5 6 7 7	k 9 (1:14) clust (25, 526, 62, 62) (25, 526,	Corean (x k28, k32, k32, k40, k50 k14, k43, k43, k43, k44, k43, k44, k43, k44, k44	Japan) Unipas Merger Merger <u>Korean</u> Unipas majority	ritic elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7 KU8 KU10 KU10 KU10 KU10 KU10 GJU1 and par of JU2
U9 U10 U11	K15, K27, K2 K1, K2 K21, K38 Revent 6(51) 0 (dutor) K1, K2, K22, K23, K23, K23, K23, K23, K23,	I ISCED0 ISCED duca ISCED duca X Czech) Unipar Merger KU7, Merger Korea) part of pa part of pa	SCEDS , start age, start age, correction of KU1, KU2 of KU3, KU3 KU9, KU10 cor KU3, KU4 KU5 KU4 KU5 KU4 KU8 KU11 rtite element rtite element rtite rtite element rtite rt	5 2 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1	Co. Co. (C. C. C	sech (x Jap s L C16, C C27, C C28, C C45, C C51, C C59, C C45, C C51, C C51, C C51, C C4, C C4, <td< td=""><td>an) inpartite dement UI and part of CU UI and part of CU CU QU part of CU QU CU QU QU QU QU QU QU QU QU QU Q</td><td>8 6 6 5, 5 5 6 6 7 7 7 1 1 6</td><td>K 9 (x 14) cheat X 52, X 26, X 72, X 52, X 72, X 72, X 53, X 54, X 72, X 54, X 54, X 54, X 54, X 54, X 54, X 54, X 54, X 54, X</td><td>Corean (x kers , K28, , K32, , K40, , K40, , K43, , K47, , K48, , K48, , K47, , K48, , K49, , K49, , K49, , K49, , K40, , K41, , J18, , J14, , J14</td><td>Japan) Unipar Merger Merger Unipan Unipan Unipan Unipan</td><td>rtite elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7 KU8 KU10 KU11 Ttite elements of JU1 and page of JU2</td></td<>	an) inpartite dement UI and part of CU UI and part of CU CU QU part of CU QU CU QU QU QU QU QU QU QU QU QU Q	8 6 6 5, 5 5 6 6 7 7 7 1 1 6	K 9 (x 14) cheat X 52, X 26, X 72, X 52, X 72, X 72, X 53, X 54, X 72, X 54, X 54, X 54, X 54, X 54, X 54, X 54, X 54, X	Corean (x kers , K28, , K32, , K40, , K40, , K43, , K47, , K48, , K48, , K47, , K48, , K49, , K49, , K49, , K49, , K40, , K41, , J18, , J14, , J14	Japan) Unipar Merger Merger Unipan Unipan Unipan Unipan	rtite elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7 KU8 KU10 KU11 Ttite elements of JU1 and page of JU2
U9 U10 U11	K25, K27, K2 K1, K2 K21, K38 K02, K38 K02, K38 K1, K2, K22, K23, K24, K25, K20, K23, K24, K25, K20, K21, K24, K25, K20, K21, K25, K27, K28, K21, K24, K27, K28, K21, K24, K27, K29, K21, K24, K24, K27, K29, K20, K24, K24, K27, K29, K20, K24, K24, K27, K29, K20, K24, K24, K27, K28, K24,	I ISCEDD ISCED duca ISCED duca (x Czech) Unipar KU7, KU7, Merger Ku7, KU7, Merger part of C	SCED5 , start age: 3, start age: 4, start a		C C C C C C C C C C C C C C C C C C C	ech (x Jag s t (C16, C27, C C28, C45, C C31, C59, C C31, C	pan) inipartite dement inipartite dement part of CU3 CU7 part of CU3 cU7 part of CU3 cU7 part of CU3 cU3 cU3 cU3 cU3 cU3 cU3 cU3 c	x 6 5 5 6 6 7 7 10 8	k 9 (x 14) class: K25, K20, K27, K29, K10, K31, K31, K42, K48, K11, K12, K142, K48, K11, K12, K142, K48, K11, K12, K142, K48, K11, K12, K14, K14, K14, K44, K64, K64, K51, K62, K51, K54, K51, K52, K51, K54, K51, K54, K54, K54, K54, K54, K54, K54, K54	Sorean (x ters , K28, , K28, K32, , K40, , K40, , K43, , K43, , K43, , K43, , K44, , K18, , K44, , K18, , K49, 5 	Superior States	ritic elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7 KU8 KU10 KU10 KU10 KU10 file elements of JU1 and pag of JU2 ad part of JU7
U9 U10 U11	K15, K27, K42 K1, K2 K21, K38 Revent 6(3.10) detarts K1, K12, K23, K24, K25 K28, K26, K27, K28, K29, K26, K27, K28, K29, K26, K27, K28, K29, K20, K21, K24, K27, K29, K40, K41, K27, K31, K44, K35, K46, K17, K46, K47, K44, K45, K19, K20, K37, K44, K45, K19, K20, K37, K44, K45, K11, K12, K15, K44, K55, K11, K12, K15, K14, K55, K11, K12, K14, K55, K14, K14, K15, K14, K	I ISCEDU ISCEDU ISCED duca x Czech) Unipar Merger KU7, Merger part of part of C	SCED5 , start age: 7, start a	5	Con Cl (5) (5) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2	ech (x Jap x L x C C16, C C27, C C28, C C45, C C51 C C59, C C41, pp D P P P pan (c Czz, II, 119, 119, 119, 119, 129)	pan) injugartite element Ul and part of CU Ul and part of CU CU Quart of CU part of CU part of CU CU CU CU part of CU and of CU and of CU and of CU and of CU and of CU cU CU part of CU part of CU cu cu cu cu cu cu cu cu cu cu	x 6 5 5 6 6 7 7 7 8 8	8 9 (x 14) chust X25, X26, X27, X29, X50, X21, X25, X26, X27, X29, X50, X31, X21, X24, X29, X21, X24, X24, X21, X24, X24, X24, X21, X24, X24, X24, X24, X25, X24, X24, X24, X24, X24, X25, X24, X24, X24, X24, X24, X24, X24, X24	Sorean (x ters , K28, , K40, , K14, , K43, , K47, , K43, , K47, , K43, , K47, , K47, , K43, , K47, ,	: Japan) Unipas Merger Merger Korean) Unipas majority JU4 an	rtite elements of KU1, KU9 of KU3, KU6 KU2 KU4 KU5 KU7 KU8 KU10 KU11 fite elements of JU1 and par of JU2 d part of JU7 JU2 and JU6
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Fig. 2: a: Overview of distributions of educational concepts classified based on the pre-defined ISCED levels. b: The unipartite clustering solution partitions educational concepts in the respective systems into clusters and what features are commonly shared among the members of the obtained clusters. c: Members of clusters restructured by the bipartite clustering solution. The "unipartite elements" columns indicate how the members of the unipartite clusters are reorganized when two educational systems are aligned.

are shared among members of each cluster in the Korean system as red color dominates in 1–1 matches, but also identifies relations across extracted clusters (e.g. KU1 and KU9). The shared features listed in Fig. 2.b show that the partitions of both the Korean- and the Japanese systems are primarily influenced by the classification of the ISCED levels, while the Czech system is strongly influenced by other criteria, e.g. whether an educational concept is targeted for adult education/part-time education or not. Accordingly the extracted clusters in the Czech system consist of members belonging to several ISCED levels. In addition, the graph drawn by the Jaccard similarities within Czech system fails to identify some of the cluster structures observable in the graph of the 1–1 matches.

In Fig. 3.b, the bipartite clustering of our framework aligns two of the educational systems in three combinations (i.e. Korea-Czech, Korea-Japan, Czech-Japan). The graphs indicate that Korea-Japan

¹http://www.uis.unesco.org/education/ISCEDmappings/Pages/default.aspx



Fig. 3: a: Results of the unipartite clustering of the three single educational systems from top to the bottom: Korea; Czech; Japan. The graphs from the first to the fourth columns depict structures in each of the four types of binary matches (i.e., 0–0, 0–1, 1–0 and 1–1). The graphs of the fifth and the sixth columns are drawn based on similarity scores (Jaccard and SMC) between all combinations of educational concepts within each single system, which are reorganized according to the extracted clusters. The structures of the 1-1 and 0-0 matches are relatively identical to the Jaccard and SMC structures. Our framework additionally provides structural information supported by all types of binary matches. Members of the extracted clusters and features shared among the cluster members are listed in Fig. 2-b. **b:** Bipartite clusterings of two educational systems: Korea-Czech; Korea-Japan; Czech-Japan. The graphs indicate how the original structures in all types of binary matches of each single system influence on the alignment of the two systems.

bipartite clustering has clearer structures in 1-1 matches than the other two combinations, as the structures in the two systems are integrated based on e.g. the ISCED levels (the classification criteria influencing on the Korean- and the Japanese unipartite clusterings). Another important finding is that the influence of the original unipartite structures is revealed in the bipartite clusterings. Fig. 2.c shows how the original unipartite clusters are merged or split when the two systems are aligned. For example, when the Korean system is aligned with the Czech system, some of the unipartite Korean clusters (KUs) are merged into one cluster, otherwise the same KUs remain as they are identified by unipartite solution. On the other hand, the majority of the unipartite Czech clusters (CUs) are split into several smaller groups and some of these groups are merged into one as a new cluster in Fig. 2.c, influenced by the unipartite Korean clusters clearly partitioned by e.g the ISCED levels. This phenomenon is supported by the graphs of 1-0 and 0-1 matches in the Korea-Czech alignment in Fig. 3.b where the Czech specific feature structures (0-1 matches) have more fine-grained stronger structures than the Korean specific feature structures (1-0 matches) with coarse weaker structures.

As outlined in Fig. 5, the 3-way clustering here identifies 10 Ko-

rean clusters (KT1-10), 25 Czech clusters (CT1-25) and 21 Japanese clusters (JT1-21). As the Korean system has the clearer and simpler unipartite partitions according to the ISCED levels and has the coarse and weaker structures in the (1-0 matches) of the bipartite clusterings in Fig. 3.b, the number of KTs obtained are substantially fewer than the other two systems. The extracted clusters are finegrained and generally well-separated, i.e. similar types of educational concepts are grouped together without irrelevant concepts. For example, the tables at the top of Fig. 4 lists feature vectors of cluster members indicating stronger interactions with the second Korean cluster (KT2). More specifically, the KT2 cluster has stronger interactions with CT11, CT13, CT21 as well as JT10, JT11, JT16 in "K-C-0" and "K-0-J" matches. The list of feature vectors demonstrate that the second Korean cluster (KT2) consists of educational concepts at the level of ISCED 5 providing Master degree and almost all eight members of KT2 possess uniform features. On the other hand, CT11, CT13, CT21 as well as JT10, JT11, JT16, all of which belong to the ISCED5 level, are divided into several sub-clusters based on different classification dimensions such as part-time, adult, degree etc. This implies that the KT2 is aligned with several CTs in the "K-C-0" matches and with several JTs in the "K-0-J" matches. In this



Fig. 4: Feature vectors of cluster members that indicate stronger interactions with the second Korean cluster (KT2).

way, the one-to-many cluster relations between KT vs. CTs or JTs are extracted. Among these interactions, KT2, CT21 and JT10/JT11 are the interactions where all three systems simultaneously interact with each other (K-C-J matches). To sum up, the 3-way clustering jointly models all 8 types of binary matches and identifies structures of interactions among the obtained clusters within and across the three systems.

4. CONCLUDING REMARKS AND FUTURE WORKS

Alignment and structuring of one or more knowledge systems usually requires similarity computations between objects belonging to the respective knowledge systems. As pointed out in [10, 19], the selection of a similarity measure influences heavily on the performance of the knowledge alignment and (re-)structuring when employing a co-clustering algorithm based on dense relational modeling [20]. The recent trend of ontological similarity measures extends Tversky's Ratio model by integrating fuzzy set representations and information content of a concept based on information theory [2]. These types of new similarity measures are theoretically relevant to the alignment and structuring of knowledge. A question is how our proposed framework is positioned in contrast to such recent progress in knowledge alignment and structuring. One argument is that our proposed framework enables the visual inspection of the overall feature structures while aligning and extracting knowledge structures at the level of statistical support. Perhaps, the most unique noteworthy argument is that our framework enables the simultaneous alignment of three or more knowledge systems since the framework is not restricted to the similarity computation between two objects. The contrastive analysis of the unipartite, bipartite and tripartite clusterings demonstrated that the rather abstract cluster like KT2 in the uniformly structured Korean system is aligned with several fine-grained clusters (i.e. subsumed clusters) in the opposed systems. This indicates that our framework enables the identification of latent ontological structures within and across the systems. Thus, one of our future challenges is to develop hierarchical ontologies linked within and across the three systems to facilitate interpretation.

Another issue to be considered is that we have in our experiment employed small datasets organized by taxonomic information. A question is the applicability of our framework to different types of datasets, i.e. from strictly structured ontologies to sparse and unstructured large datasets where model inference will be substantially more challenging. In addition, we need to investigate objective evaluation criteria of the results, which has been considered outside the scope of this paper. A noteworthy remark is that our unipartite solution enables to assess whether an input dataset is structured or unstructured as shown in our experiment. This information itself is useful when two or more datasets are to be aligned afterwards. Such additional functionality can also be assessed when testing the applicability of our framework with different types of datasets.

5. REFERENCES

- A. Isaac, L. V. D. Meij, S. Schlobach, and S. Wang, "An empirical study of instance-based ontology matching," *The Semantic Web, Lecture Notes in Computer Science*, vol. vol4825, pp. 253–266, 2007.
- [2] V. Cross, X. Yu, and X. Hu, "Unifying ontological similarity measures: A theoretical and empirical investigation," *International Journal of Approximate Reasoning*, vol. vol54, pp. 861–875, 2013.
- [3] C. P. Cheng, G. T. Lau, K. H. Law, J. Pan, and A. Jones, "Regulation retrivial using industry specific taxonomies," in *AI and Law*, vol. 16, pp. 277–303. 2008.
- [4] J. Euzenat and P. Shvaiko, Ontology Matching, Springer, 2007.
- [5] D. Ngo, Z. Bellahsene, and K. Todorov, "Extended tversky similarity for resolving terminological heterogeneities across ontologies," OTM 2013, Lecture Notes in Computer Science, vol. vol8185, pp. 711–718, 2013.
- [6] P. Jaccard, "Distribution de la flore alpine dans le bassin des dranses et dans quelques regions voisines," in *Bulletin de la societe vaudoise des sciences naturelles, vol.37*, pp. 241–272. 1901.
- [7] A. Tversky, "Features of similarity," *Psychological Review*, no. 4, pp. 327–352, 1977.
- [8] G. Pirrò and N. Seco, "Design, implementation and evaluation of a new semantic similarity metric combining features and intrinsic information content," in OTM Conferences (2), 2008, pp. 1271–1288.
- [9] Pirrò G. and J. Euzenat, "A feature and information theoretic framework for semantic similarity and relatedness," in *International Semantic Web Conference* (1), 2010, pp. 615–630.
- [10] F. K. Glückstad, T. Herlau, M. N Schmidt, and M. Mørup, "Cross-categorization of legal concepts across boundaries of legal systems: in consideration of inferential links," in *AI and Law*. Springer, 2013.
- [11] S. Wasserman and C. Anderson, "Stochastic a posteriori blockmodels: Construction and assessment," 1987.
- [12] K. Faust and S. Wasserman, "Blockmodels: Interpretation and evaluation," 1992.
- [13] C. Kemp, J. B. Tenenbaum, T. L. Griffiths, T. Yamada, and N. Ueda, "Learning systems of concepts with an infinite relational model," in AAAI, 2006, vol. 3, p. 5.
- [14] Z. Xu, V. Tresp, K. Yu, and H.P. Kriegel, "Learning infinite hidden relational models," *Uncertainty in Artificial Intelligence (UAI2006)*, 2006.
- [15] D. Aldous, "Exchangeability and related topics," École d'Été de Probabilités de Saint-Flour XIII1983, pp. 1–198, 1985.
- [16] J. Pitman et al., "Combinatorial stochastic processes," Tech. Rep., Springer, 2002.
- [17] S. Jain and Radford M Neal, "A split-merge markov chain monte carlo procedure for the dirichlet process mixture model," *Journal of Computational and Graphical Statistics*, vol. 13, no. 1, 2004.
- [18] D.B. Dahl, "Sequentially-allocated merge-split sampler for conjugate and nonconjugate dirichlet process mixture models," *Journal of Computational and Graphi*cal Statistics, vol. 11, 2005.
- [19] F. K. Glückstad, T. Herlau, M. N Schmidt, and M. Mørup, "Unsupervised knowledge structuring: Application of infinite relational models to the fca visualization," in *Proc. 9th International Conference on Signal Image Technology and Internet Based Systems (SITIS 2013), Kyoto, Japan, 2013.*
- [20] T. Herlau, M. Mørup, M. N. Schmidt, and L. K. Hansen, "Modelling dense relational data," in *IEEE International Workshop on Machine Learning for Signal Processing (MLSP), Santander, Spain.* 2012.



Fig. 5: 3-way clustering of the three educational systems (Korea-Czech-Japan). The graphs overview how the 10 Korean clusters (the number of matches are averaged among members of each cluster) interact with the other two systems. The 10 rows from the top to the bottom refer to the Korean clusters from KT1 to KT10, and the 8 columns from the left to the right refer to 111, 011, 101, 110, 100, 010, 001, and 000 matches. For convenience, these combinations are denoted as [KCJ, 0CJ, K0J, KC0, K00, 0C0, 00J, 000] in order to specify which systems interact with each other.