CS11-737 Multilingual NLP

Typology: The Space of Languages

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https://lileicc.github.io/course/11737mnlp23fa/

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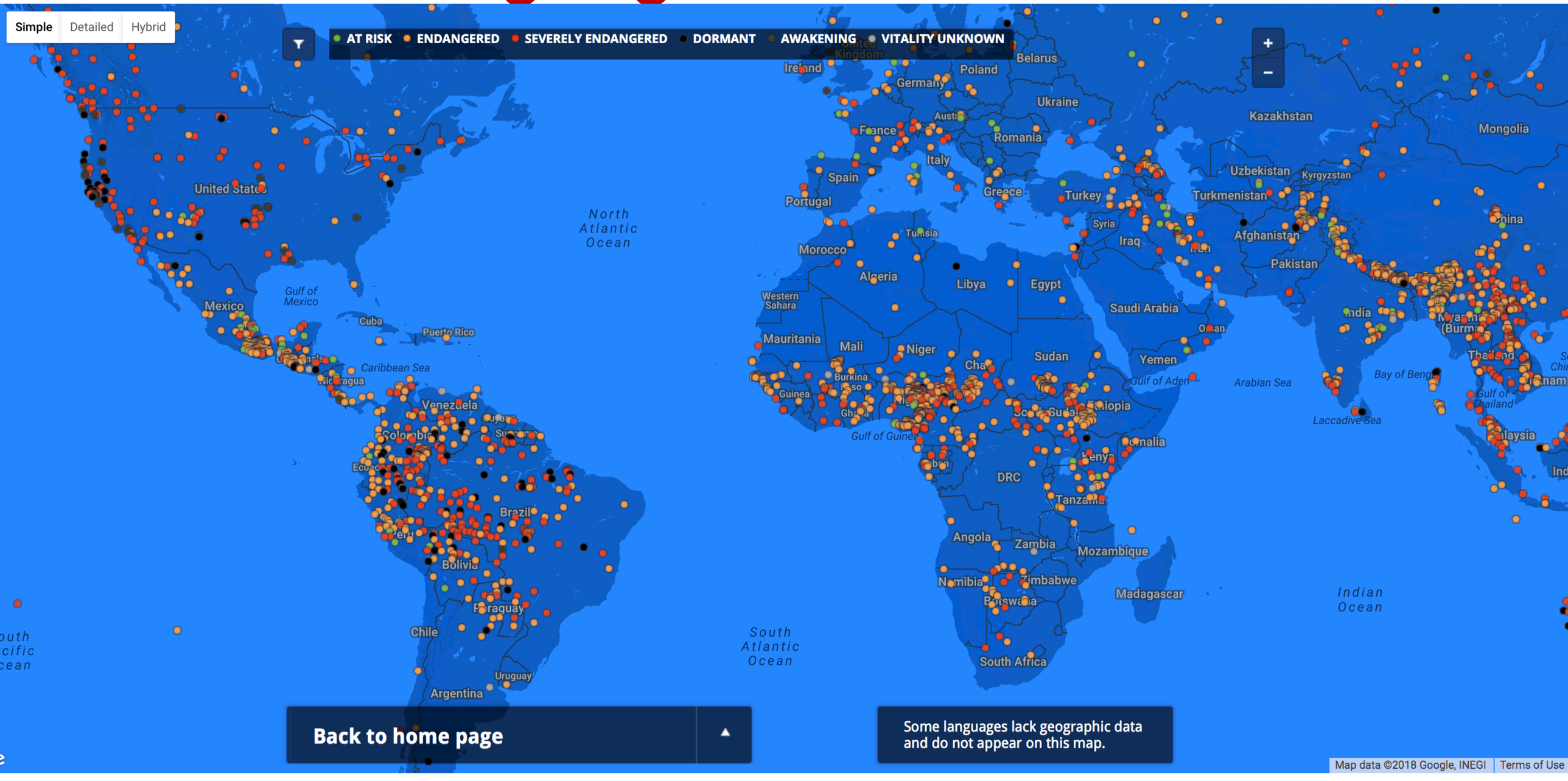
many slides from Yulia Tsvetkov and Alan Black

Languages of the World



Linguistic Diversity

- There are about 460 languages in India
- Population: 1.42 billion
- 22 official languages

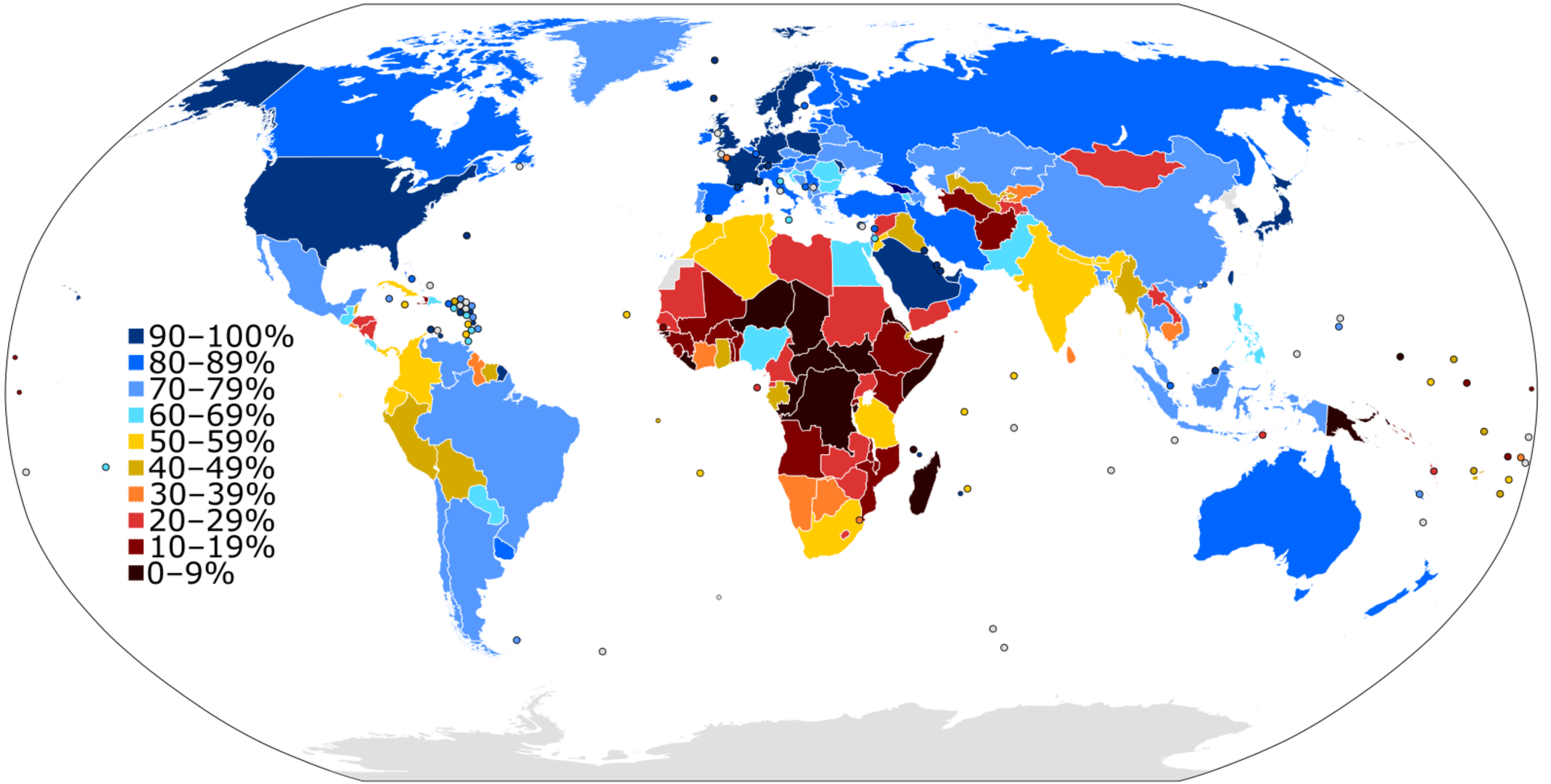
Linguistic Diversity

- Africa is continent with a very high linguistic diversity
- 1.5-2k African languages from 6 language families
- Population: 1.39 billion

Linguistic Diversity

- Population: 1.4 billion
- Total spoken languages in China: 302
- Not every language has a writing system
- Yuen Ren Chao speaks 40 languages (33 Chinese dialects)

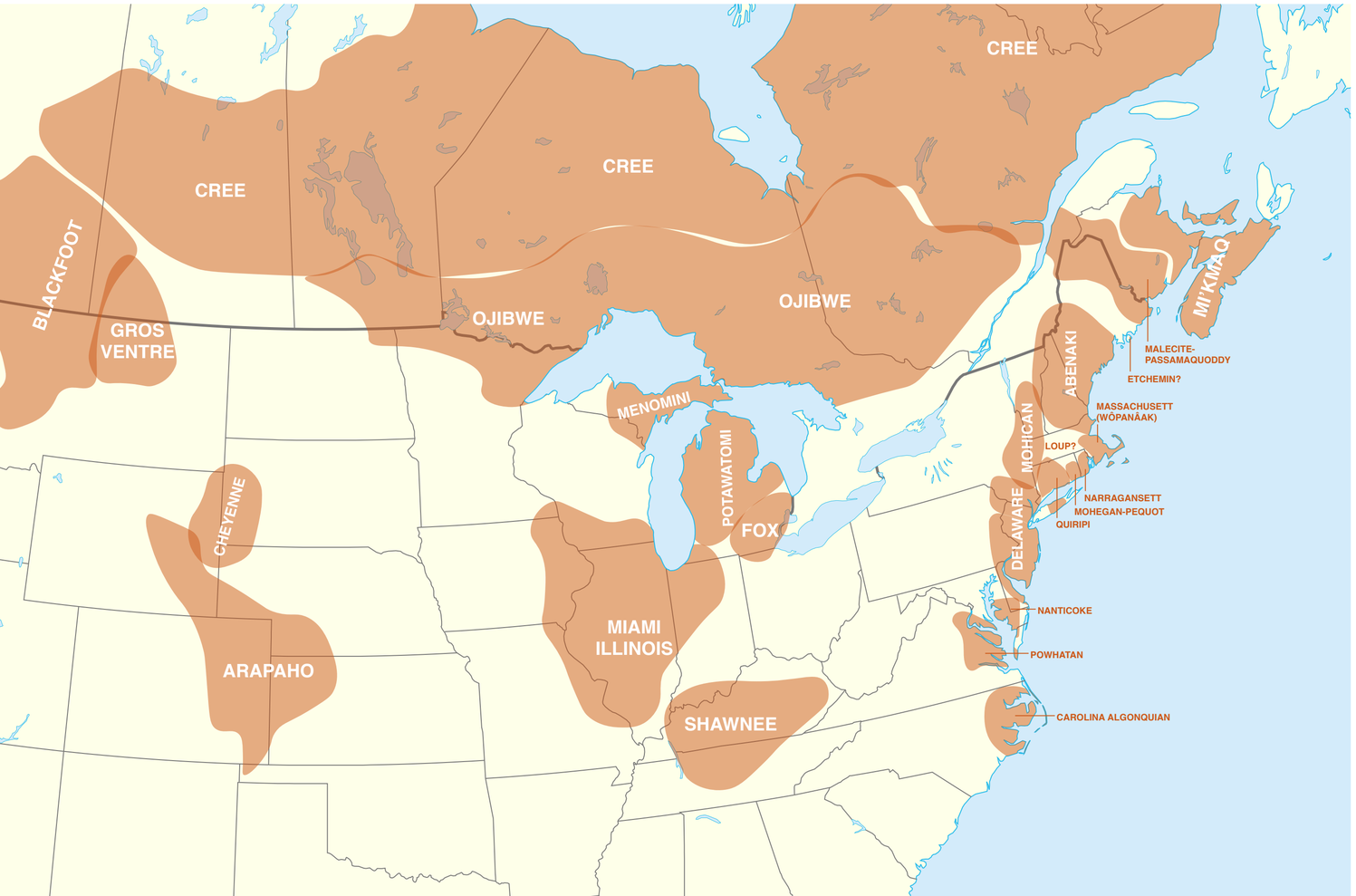
Low-resource Language Processing



40% of world's population: South Asia - 1.75 billion, Africa - 1.3 billion, etc.

Indigenous Languages in Pittsburgh

- Iroquois (Seneca, Mohawk, etc)
- Shawnee



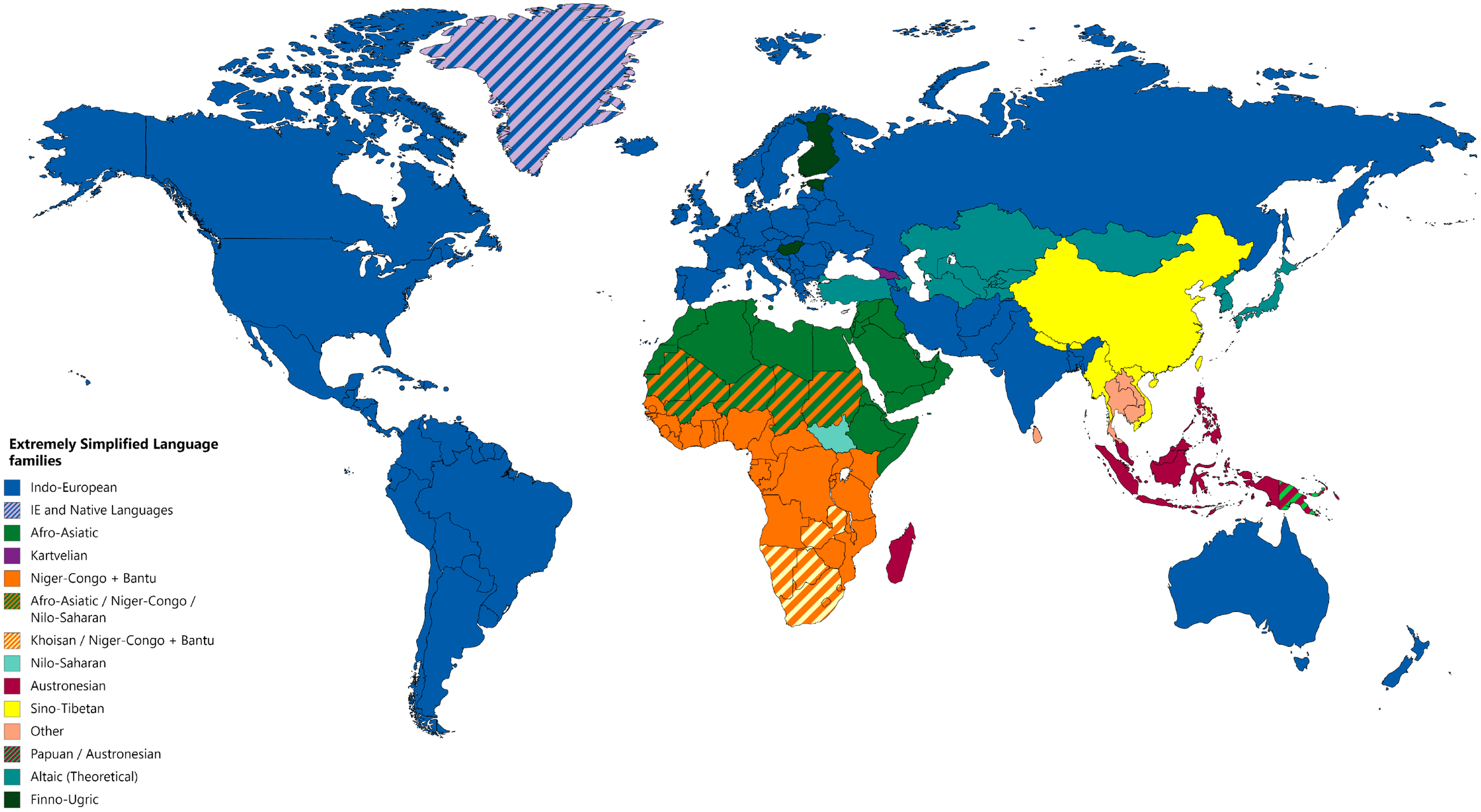
Language Similarity

- Word overlap and sub-word overlap
  - Russian – Русский
  - Ukraininan – Українська
  - Chinese – 中文
  - Korean – 한국어
  - Vietnamese – Tiếng Việt
  - Georgian – ქართული
  - Japanese – 日本語
  - Turkish – Türk
  - Hebrew עִברִית
  - Arabic –ی(عرب
  - Hindi – हिन्दी
  - Xhosa
- Areal similarity: www.glottolog.org
- Demographic similarity

Genealogical similarity

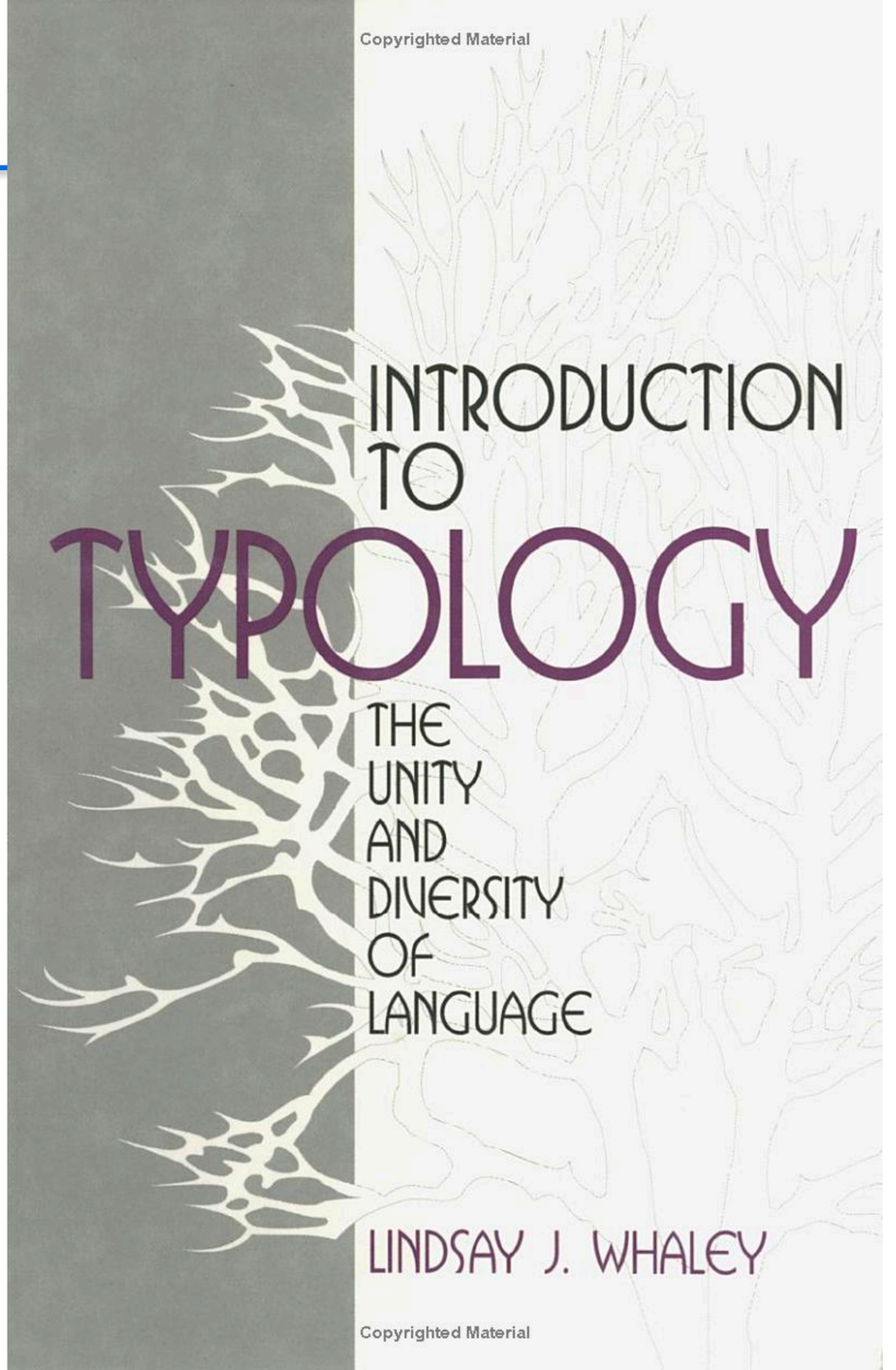
- Niger-Congo (1,542 languages, 21.7%)
- Austronesian (1,257 languages, 17.7%)
- Trans-New Guinea (482 languages, 6.8%)
- Sino-Tibetan (455 languages)
- Indo-Enropean (448 languages)
- Australian (381 languages)
- Afro-Asiatic (377 languages)
- Nilo-Saharan (206 languages)
- Oto-Manguean (178 languages)
- Austroasiatic (167 languages)
- Kra-Dai (91 languages)
- Dravidian (86 languages)
- Tupian (76 languages)

www.ethnologue.com

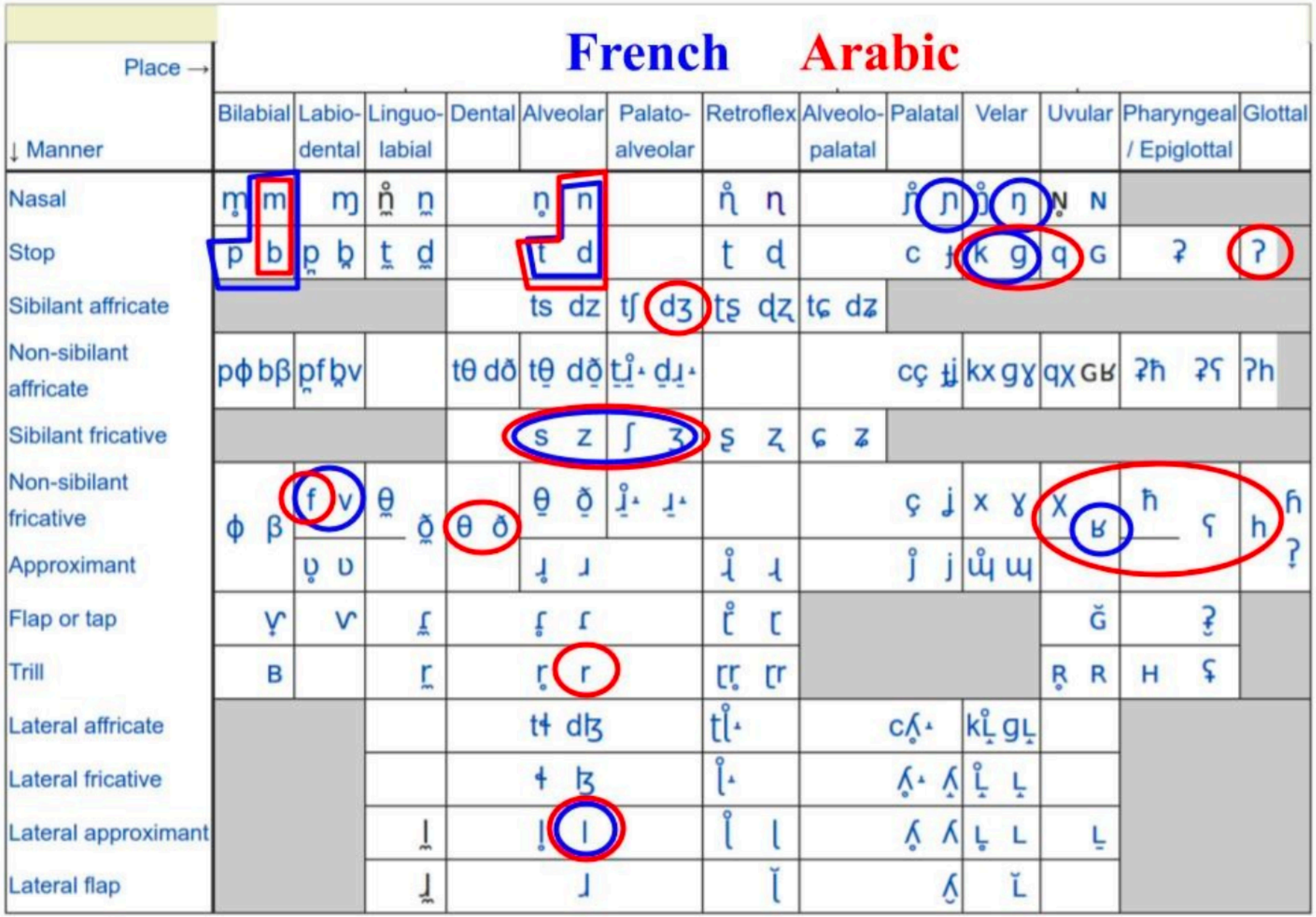


Typological Similarity

- Linguistic typology: classification of languages according to their functional and structural properties
  - explains common properties across languages
  - explains structural diversity across languages
- “The classification of languages or components
of languages based on shared formal characteristics.”



Linguistic Typology Example: phonology



Tonal Languages

- Different tones to distinguish words and inflections
- Example: Chinese, Vietnamese, Wolof, Fulani, Navajo

Simplified: 妈妈骂马的麻吗?

Traditional: 媽媽罵馬的麻嗎?

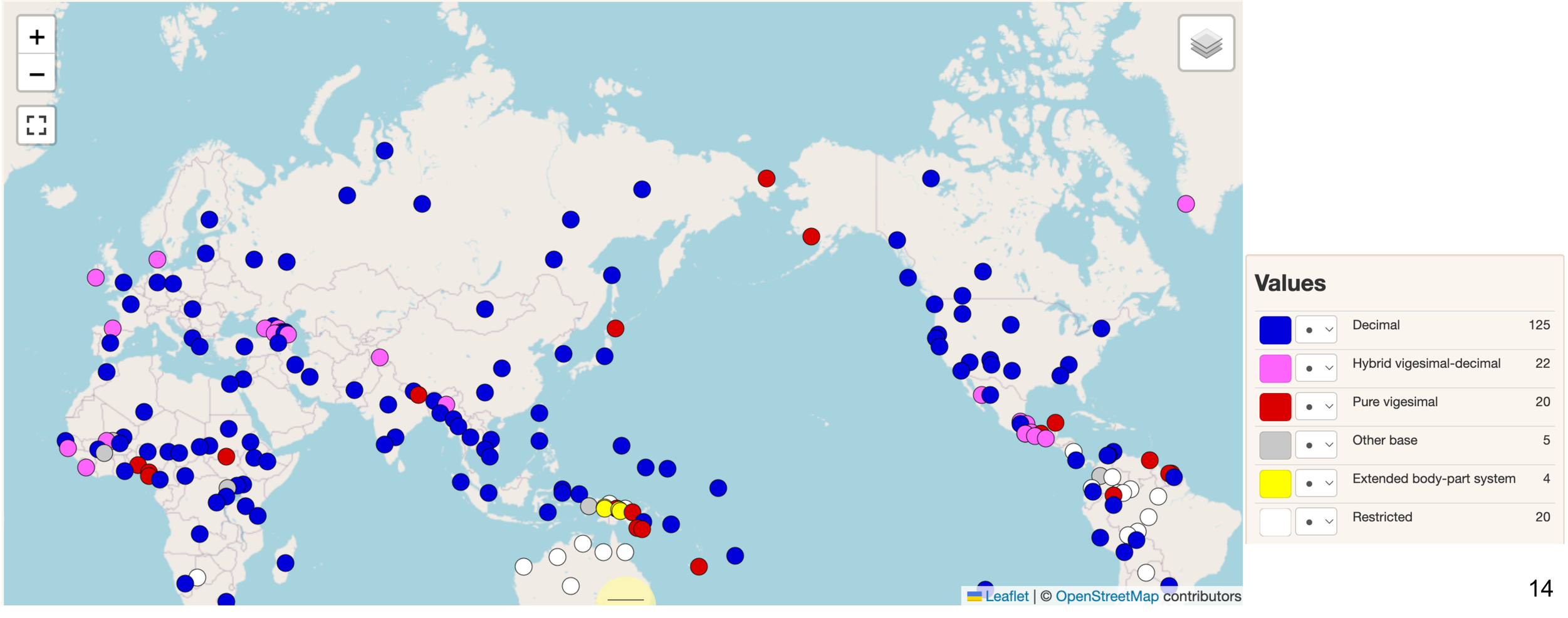
Pinyin: Māma mà mǎde má ma?

IPA /máma mâ màtə mǎ ma/

Translation: 'Is mom scolding the horse's hemp?'

Linguistic Typology Example: Numerals

- Feature 131A: Numeral Bases
- wals.info/chapter/131



WALS

- The World Atlas of Language Structures Online
- 2662 Languages
- 192 Features/Attributes

ID#	Feature Name	Category	Feature Values
1	Consonant Inventories	Phonology (19)	{1:Large, 2:Small, 3:Moderately Small, 4:Moderately Large, 5:Average}
23	Locus of Marking in the Clause	Morphology (10)	{1:Head, 2:None, 3:Dependent, 4:Double, 5:Other}
30	Number of Genders	Nominal Categories (28)	{1:Three, 2:None, 3:Two, 4:Four, 5:Five or More}
58	Obligatory Possessive Inflection	Nominal Syntax (7)	{1:Absent, 2:Exists}
66	The Perfect	Verbal Categories (16)	{1:None, 2:Other, 3:From 'finish' or 'already', 4:From Possessive}
81	Order of Subject, Object and Verb	Word Order (17)	{1:SVO, 2:SOV, 3:No Dominant Order, 4:VSO, 5:VOS, 6:OVS, 7:OSV}
121	Comparative Constructions	Simple Clauses (24)	{1:Conjoined, 2:Locational, 3:Particle, 4:Exceed}
125	Purpose Clauses	Complex Sentences (7)	{1:Balanced/deranked, 2:Deranked, 3:Balanced}
138	Tea	Lexicon (10)	{1:Other, 2:Derived from Sinitic 'cha', 3:Derived from Chinese 'te'}
140	Question Particles in Sign Languages	Sign Languages (2)	{1:None, 2:One, 3:More than one}
142	Para-Linguistic Usages of Clicks	Other (2)	{1:Logical meanings, 2:Affective meanings, 3:Other or none}

Dryer, Matthew S. & Haspelmath, Martin (eds.) 2013.
The World Atlas of Language Structures Online.
Leipzig: Max Planck Institute for Evolutionary Anthropology.

Comparing Language Similarity across Genetic and Typologically-Based Groupings

Ryan Georgi, Fei Xia, William Lewis, 2010

Automatic Prediction of Typological Features

- Morphosyntactic annotation projection
  - Sentence and treebank alignments to project feature annotations from similar languages
- Unsupervised and semi-supervised feature propagation
  - Hierarchical typological clustering and majority value assignment
  - Language-family based nearest neighbor projection
  - Matrix completion
- Supervised Learning
  - Logistic regression/Support Vector Machines/GBDT
  - Determinant point process with neural features
- Cross-lingual distributional feature alignment

Ponti, E.M., O'horan, H., Berzak, Y., Vulić, I., Reichart, R., Poibeau, T., Shutova, E. and Korhonen, A., 2019. Modeling language variation and universals: A survey on typological linguistics for natural language processing. *Computational Linguistics*, 45(3), pp.559-601.

Typological Databases

Name	Levels	Coverage	Feature Example
World Atlas of Language Structures (WALS)	Phonology, Morphosyntax, Lexical semantics	2,676 languages; 192 attributes; 17% values covered	ORDER OF OBJECT AND VERB Amele: OV (713) Gbaya Kara: VO (705)
Atlas of Pidgin and Creole Language Structures (APiCS)	Phonology, Morphosyntax	76 languages; 335 attributes	TENSE–ASPECT SYSTEMS Ternate Chabacano: purely aspectual (10) Afrikaans: purely temporal (1)
URIEL Typological Compendium	Phonology, Morphosyntax, Lexical semantics	8,070 languages; 284 attributes; ~439,000 values	CASE IS PREFIX Berber (Middle Atlas): yes (38) Hawaaian: no (993)
Syntactic Structures of the World's Languages (SSWL)	Morphosyntax	262 languages; 148 attributes; 45% values covered	STANDARD NEGATION IS SUFFIX Amharic: yes (21) Laal: no (170)
AUTOTYP	Morphosyntax	825 languages; ~1,000 attributes	PRESENCE OF CLUSIVITY !Kung (Ju): false Ik (Kuliak): true
Valency Patterns Leipzig (ValPaL)	Predicate–argument structures	36 languages; 80 attributes; 1,156 values	TO LAUGH Mandinka: 1 > V Sliammon: V.sbj[1] 1
Lyon–Albuquerque Phonological Systems Database (LAPSyD)	Phonology	422 languages; ~70 attributes	ɗ AND ʈ Sindhi: yes (1) Chuvash: no (421)
PHOIBLE Online	Phonology	2,155 languages; 2,160 attributes	m Vietnamese: yes (2053) Pirahã: no (102)
StressTyp2	Phonology	699 languages; 927 attributes	STRESS ON FIRST SYLLABLE Koromfé: yes (183) Cubeo: no (516)
World Loanword Database (WOLD)	Lexical semantics	41 languages; 24 attributes; ~2,000 values	HORSE Quechua: *kaballu* borrowed (24) Sakha: *sɨlgɨ* no evidence (18)
Intercontinental Dictionary Series (IDS)	Lexical semantics	329 languages; 1,310 attributes	WORLD Russian: *mir* Tocharian A: *ārkiśoṣi*
Automated Similarity Judgment Program (ASJP)	Lexical semantics	7,221 languages; 40 attributes	I Ainu Maoka: *co7okay* Japanese: *watashi*

Ponti, E.M., O'horan, H., Berzak, Y., Vulić, I., Reichart, R., Poibeau, T., Shutova, E. and Korhonen, A., 2019. Modeling language variation and universals: A survey on typological linguistics for natural language processing. *Computational Linguistics*, 45(3), pp.559-601.

URIEL

- URIEL typological compendium
  - Phonology, morphosyntax, lexical semantics
  - 8,070 languages, 284 attributes, $439,000 values
- lang2vec representations from URIEL
  - https://pypi.org/project/lang2vec/

Patrick Littell, David R. Mortensen, Ke Lin, Katherine Kairis, Carlisle Turner, Lori Levin. 2017. URIEL and lang2vec: Representing languages as typological, geographical, and phylogenetic vectors. In Proc. EACL

Malaviya, C., Neubig, G. and Littell, P., 2017. Learning language representations for typology prediction. In Proc. EMNLP

Linguistic universals

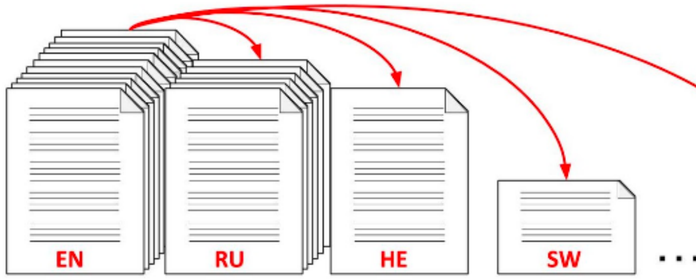
- All languages have vowels and consonants
- All (or at least nearly all) languages of the world also make a distinction between nouns and verbs

Approaches to low-resource/multilingual NLP

- Manual curation and annotation of large-scale resources for thousands of languages in infeasible or prohibitively expensive
- Unsupervised learning (Snyder and Barzilay 2008; Cohen and Smith, 2009; Snyder, 2010; Vulić, De Smet, and Moens 2011; Spitkovsky et al., 2011; Goldwasser et al., 2011; Titov and Klementiev 2012; Baker et al., 2014, and many others)
- Self-supervised/Pre-training and Transfer

Approaches to low-resource/multilingual NLP

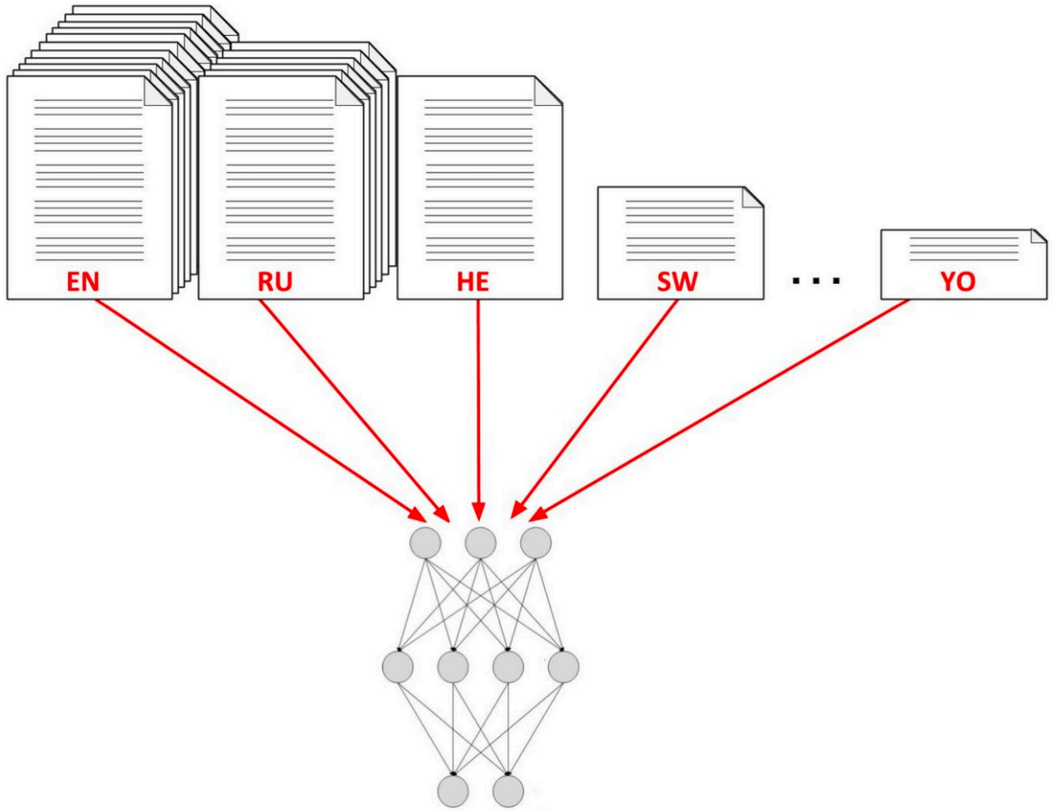
- Cross-lingual transfer learning – transfer of resources and models from resource-rich source to resource-poor target languages
  - Transfer of annotations (e.g., POS tags, syntactic or semantic features) via cross-lingual bridges (e.g., word or phrase alignments)
  - Transfer of models – train a model in a resource-rich language and adapt (e.g. fine-tune) it in a resource-poor language



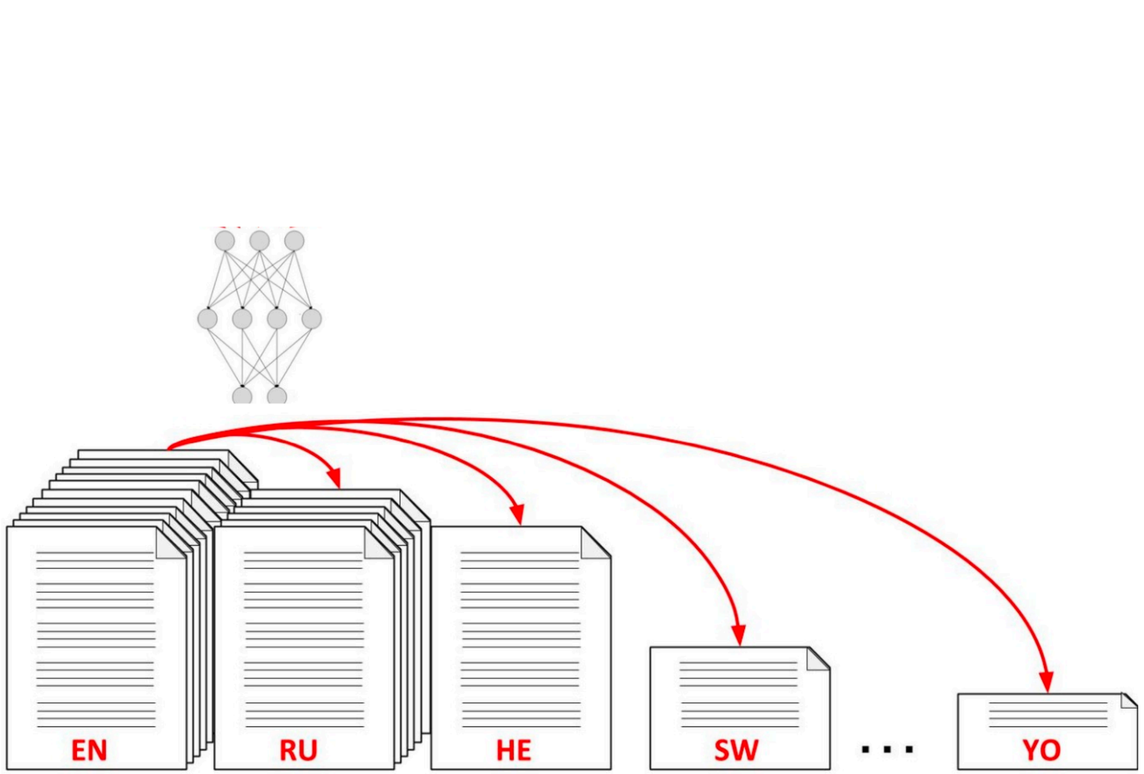
- Zero-shot learning – train a model in one domain and assume it generalizes more or less out-of-the-box in a low-resource domain
- Few shot learning – train a model in one domain and use only few examples from a low-resource domain to adapt it

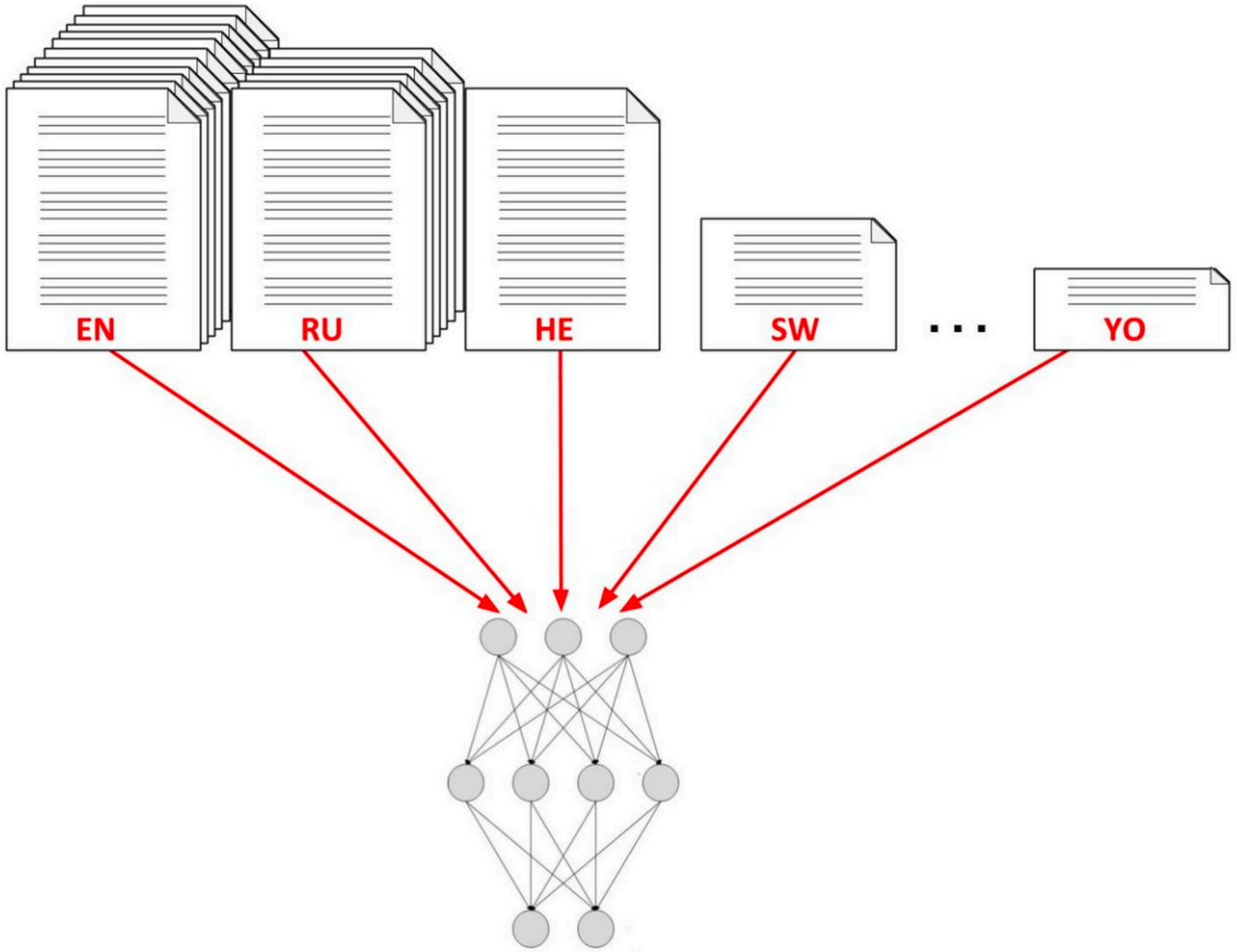
Approaches to low-resource/multilingual NLP

- Joint multilingual learning – train a single model on a mix of datasets in all languages, to enable data and parameter sharing where possible



Choosing transfer languages





Lin, Y.H. et al. 2019. Choosing Transfer Languages for Cross-Lingual Learning. In Proc. ACL. https://arxiv.org/pdf/1905.12688.pdf

Open research problems

- how to extract typological features automatically from existing multilingual resources such as Universal Dependency treebank, UniMorph, Wikipedia, or Bible corpora
- how to accurately predict typological knowledge while controlling for genealogical and areal biases
- how to incorporate linguistic typology into neural models
- trained models using typological knowledge
- how to alleviate negative transfer and catastrophic forgetting in multilingually (almost in all multilingual models)

Further readings

- Papers in tracks on morphology/phonology or multilinguality at *CL conferences
- Workshops: SIGMORPHON, SIGTYP, ComputEL, AfricaNLP, DeepLo, etc.

Reading and Discussion

- Ponti, E.M., O'horan, H., Berzak, Y., Vulić, I., Reichart, R., Poibeau, T., Shutova, E. and Korhonen, A., 2019. Modeling language variation and universals: A survey on typological linguistics for natural language processing. Computational Linguistics, 45(3), pp.559-601.
- Discussion Question:
  - What are some unique typological features of a language that you know regarding phonology, morphology, syntax, semantics, pragmatics?