Uhlelo Lwekhompyutha Lwe*Python* Kanye Nekhophasi YesiZulu Njengezinsiza Zokuthuthukisa Kanye Nokuphusisa Ulimi LwesiZulu

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Iqoqa

Uhlelo lwekhompyutha lwe*Python* lusetshenziselwa ukusungula kanye nokubhala izinhlelo zamakhompyutha zobuxhakaxhaka bokuxhumana kanye nezomakhalekhukhwini. Lolu hlelo oluthandwa kangaka selusetshenziswe ezindaweni eziningi ezifana nesayensi yezilimi, lapho khona okufundwa ngezilimi zabantu kuphinde futhi kuhlaziywe izilimi zabo bona abantu. Izilimi eziningi emhlabeni sezihlaziywe, zaphinde futhi zatolikwa ngaphansi kwezinhlelo zayo i*Python*. Kodwa-ke, ezinye izilimi, ezifana nolimi lwesiZulu, bezingakacutshungulwa ngaphansi kwezinhlelo ezifana nayo i*Python*. Lolu cwaningo luhlaba umkhosi ekubalulekeni kokuhlongoza isiZulu ngaphansi kohlelo lwe*Python*. Okubalulekile futhi ukuthi kulo lolu cwaningo kuyavela kahle kamhlophe ukuba singayisebenzisa kanjani le*Python* ukuhluza, noma ukukhaliphisa ulimi lwesiZulu. Ikhophasi nayo idlala indima enkulu ekulolongeni amakhompyutha ukuba alufunde ulimi lwabantu futhi aluphimise. Ikhophasi-ke, kulolu cwaningo, isetshenziswe njengomhlahlandlela wokuchasisa ucwaningo. Umhlahlandlela wekhophasi yiwo olawula ukusetshenziswa kwezinsizanhlelo ze*Python* ekucubunguleni imibhalo yesiZulu, kulolu cwaningo. Ukufaka isiZulu ebuxhakaxhakeni bamakhompyutha obuhambelana nenhlalo kanye nesimo sabantu kanye nezinsiza zobuxhakaxhaka bokuxhumana yikho okuyohlomulelisa lolu limi ukuba lwephuse futhi luthuthuke.

Amagama asemqoka: I*Python*; IsiZulu; Ikhophasi; Ukufunda kanye nokufundisa ulimi lwesiZulu; Ukuhlela ngekhompyutha; Izinhlelo zekhompyutha; Izinsizanhlelo zamakhompyutha

Print ISSN 1023-1757; Electronic ISSN: 2519-5476; DOI https://doi.org/10.29086/2519-5476/2024/v31n2a13

The Python Programming Language and the IsiZulu Corpus as Tools for the Development and Intellectualisation of isiZulu

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Abstract
The Python programming language is used to write mobile and computer software programs. This popular programming language has been used in linguistics where research into human languages takes place. Most computer software programs are written using such programming languages as Python. Most human languages of the world have been analysed and described using computer tools that are compatible with Python. However, within the realm of computation not much work has been done to analyse and describe resource-scarce languages such as isiZulu.. This study seeks to inspire work on using programming languages such as Python to analyse and provide descriptions of isiZulu within the context of computation. Examples of how to analyse isiZulu using Python are shown in this article, Further, analysing isiZulu within computation entails the development and thus intellectualisation of the language. Corpora play an important role as datasets in a data-driven, statistical-based model of machine learning. Therefore, the concept of a corpus has been adopted as a theoretical frameworkin this study. Within the framework of a corpus, Python tools are applied to isiZulu and its selected text samples. Contextualising the analyses and the descriptions of isiZulu to computation will assist in the development and intellectualisation of this language.

Keywords: Python; isiZulu; Corpus; isiZulu pedagogy; Programming; Computer software programs; Computer algorithms, Computer modules

Isingeniso
Umsebenzi wokwakha izinhlelo zamakhompyutha uyaye ubonakale njengomsebenzi wonjiniyela, abantu abakhonze ukuphila ngokusebenzisa amathuluzi (kanye nezandla zabo) ukwenza izinto. Lolu hlobo lokusebenza luyaye lubonakale lungahambisani kahle nendlela yokusebenza kanye nendlela yokufunda etholaka kakhulu esikoleni sezesintu kanye nasesikoleni

sezobuciko. Ukufunda ngokwakha izinhlelo zamakhompyutha ngaso sonke isikhathi kumatanyiswa neziko lezikole zobunjuniyela. Kungakuhle ukuba ezikweni lezikole ezifunda ngolimi lwesintu kube khona uphiko olubhekana nomsebenzi wokufundisa amakhompyutha ulimi lwabantu. Lolu cwaningo luhlose ukufaka ugqozi lokuba kuqalwe ukuthungathwa kwezindlela amakhompyutha angasetshenziswa ngazo ekucwaningeni nasekuthuthukisweni kwesiZulu. Abantu abaphuma ezikweni lezikole zesintu, kanye nasezikweni lezikole zobuciko, kumele baqale babe nentshisekelo futhi baqale ukufunda ngezindlela zokwakha izinhlelo zamakhompyutha. Ikakhulukazi uma sikhuluma ngezezilimi, abantu abafunda ngezezilimi kumele bafunde ukwakha izinhlelo zamakhompyutha ukuze bakwazi ukufundisa amakhompyutha ulimi lwemvelo lwabantu. Enye inhloso eyingqikithi lapha wukuba amakhompyutha nawo uqobo kumele alufunde ulimi lwabantu, akwazi futhi ukuluphimisa. Okunye futhi okubalulekile wukuba kule ndlela yesimanje yokufunda nokufundisa, lapho abantu besebenzisa amakhompyutha kakhulu khona uma befunda noma benza ucwaningo, akungabazeki ukuba izinhlelo zamakhompyutha, ezihambelana nolimi labomdabu, kumele ziqale zibunjwe, bese ziyasatshalaliswa ukuba zisetshenziswe wuwonkewonke.

Ngakho-ke, masiqale sibone ukwakha izinhlelo zamakhompyutha njengento ehambelanayo nolimi lwaboHlanga, kanti futhi nanjengento ehambelana nemfundo ephakeme yeziko lezesintu kanye neziko lezobuciko. Kodwa-ke okubonakalayo, futhi okuthembisayo wukuba ezikweni lezesintu, amakhompyutha aseyaqala ayamukeleka ngaphansi kompheme obizwa ngokuthiwa yi*Digital Humanities*. Ukusukela manjena-ke, izinhlelo zokwakha izinhlelo zamakhompyutha ezifana no*Python*, akusizo nje kuphela izinhlelo ezingamathuluzi onjiniyela, kepha lezi seziyizinhlelo ezingamathuluzi kawonkewonke.

Ikhophasi kanye namakhompyutha kuyaye kuhambisane esikhathini esiningi. Lolu cwaningo lusebenzise ikhophasi njengomhlahlandlela lapha. Esigabeni sesibili lapha, kuchazwe kwenatshwa ngomhlahlandlela wekhophasi osetshenzisiweyo kulolu cwaningo. Izinhlelo zamakhompyutha okunye futhi okubalulekile kulolu cwaningo nokuwumgogodla kwalo lolu cwaningo. I*Python* inohlelo olubizwa ngama*regular expressions.* Uhlelo lwama*regular expressions* luyingqikithi ebalulekile kulolu cwaningo. Kulolu cwaningo, u-*re* usetshenzisiwe ukuze kuhlaziywe imibhalo yesiZulu. Inhlosongqangi lapha wukutshengisa ukuba izinhlelo ze*Python* zingasetshenziswa kanjani

ukuhlaziya noma ukucubungula imibhalo yolimi lwesiZulu. Kulolu cwaningo kuphinde kwalotshwa izibonelo lapho khona izinhlelo ezitholakala kwi*Python* zisetshenziselwe ukucwaninga imibhalo yesiZulu.

Olunye ucwaningo okumele lwenziwe wukuba zingakhiwa kanjani izinhlelo zamakhompyutha eziqonda noma eziqondene ngqo nolimi lwesiZulu kuphela. Ucwaningo lwangaphambilini lwekhophasi yesiZulu[1] lusebenzise amathuluzi afana no*wordsmith tools,* okanye o-*antconc* kanye no*sketch engine* ukuhlaziya imibhalo yesiZulu. Lolu cwaningo lona lusebenzisa i*Python* nohlelo lwama*regular expressions* ukuhlaziya imibhalo yesiZulu. Akuqali ngalolu cwaningo ukuba ulimi lwesiZulu lucutshungulwe ngaphansi kohlelo lwe*Python.* Olunye ucwaningo oseluhlaziye isiZulu ngaphansi kohlelo lwe*Python* lutholakala kuKeet kanye noXakaza (2017).

Okuhlalukayo kulolu cwaningo wukuba ezinye izinhlelo ze*Python* azikhethi limi. Isibonelo nje, kwaziwa ukuthi izinhlelo zamakhompyutha zokuhlaziya ulimi zisebenza kahle uma kuhlaziywa ulimi lwesiNgisi. Okuvelayo lapha-ke, wukuthi ezinye zezinhlelo ze*Python* zisebenza kahle impela yize noma kuhlaziywa ulimi lwesintu. Lokhu kusho ukuthi izinsizanhlelo ezifana no-*re.search,* o-*re.compile,* o-*re.findall* kanye no-*re.sub* zisebenza kahle futhi uma kuhlaziywa imibhalo yesiZulu. Okuvelayo futhi wukuthi esiNgisini, amakhompyutha ayakwazi ukuba aguqule igama, aveze umsuka walo[2]. Ngeshwa, esiZulwini, asikakwazi ukukwenza lokhu. Ngaphezu kwalokho, amakhompyutha aseyakwazi ukuba aveze izingcezu zenkulumo zamagama esiNgisi. EsiZulwini, umsebenzi wokufundisa amakhompyutha izingcezu zenkulumo kusamele uqhubeke, uqhutshwe, bese uyaphothulwa[3]. Lokhu kusho khona ukuthi muningi umsebenzi okusamele wenziwe esiZulwini.

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[1] Ucwaningo olushicilelwe olumayelana nekhophasi yesiZulu lutholakala kuKhumalo (2020).

[2] Isibonelo sokuguquguqula igama ukuba kuvele umsuka walo: umuntukazana – umuntu. Igama elithi *'lemmatisation'* lichaza umsebenzi amakhompyutha akwazi ukuwenza wokuveza umsuka wegama.

[3] Umsebenzi wokuhlela amagama esiZulu ngokwezingcezu zenkulumo usuqalile. Lo msebenzi oshicilelweyo utholakala kuPretorius noBosch (2003), kanye nakwabanye abacwaningi. Izinhlelo ezihlela amagama esiZulu ngokwezingcezu zenkulu zikwenza lokhu ngokusebenzisa amatemu esiNgisi. Ngakho, ngokwalezi zinhlelo, uma zihlela igama elithi 'umuntu,' azisho ukuthi igama elithi 'umuntu' yibizo, kepha zithi igama elithi 'umuntu' yi*noun.*

Uma sekuziwa kwezamakhompyutha, isiZulu kanye nezinye izilimi zomdabu azikakacutshungulwisisa kahle ngaphansi kwezinhlelo zamakhompyutha. Enye inhlosongqangi yalolu cwaningo wukuvusa ugqozi lokuba kuqalwe kucutshungulwe isiZulu ngaphansi kwezinhlelo zamakhompyutha ezikhethekileyo zokuhlaziya kanye nokwakha ulimi.

Kulona lolu cwaningo kukhulunywa ngomhlahlandlela osetshenzisiwe ngenkathi kwenziwa lolu cwaningo. Okubalukile okuvelayo wukuthi umhlahlandlela olandelwa yilolu cwaningo ngowekhophasi. Ikhophasi akusiyo imibhalo nje kuphela eqoqelwe ndawonye. Kepha ikhophasi, njengenjulalwazi, iyakwazi ukuba ibe sesigabeni somhlahlandlela[4]. I*Python* idlala indima enkulu kulolu cwaningo njengesikhali somsebenzi esisetshenziselwe ukuhlaziya imininigwane yalolu cwaningo, okuyimibhalo yesiZulu. Ngalokho-ke, lapha sinikeza nencazelo yokuthi iyini i*Python.* Lolu cwaningo luphinde luhlaziye iminingo luphinde futhi lunikeze nemiphumela yocwaningo.

Umhlahlandlela Osetshenzisiwe Kulolu Cwaningo

Umhlahlandlela osetshenzisiwe kulolu cwaningo ngowekhophasi. Ikhophasi ingasetshenziswa njengethuluzi lokuthuthukisa kanye nokucubungula ulimi. Ikhophasi ingaphinde futhi isebenze njengomhlahlandlela wokucwaninga ulimi. Okubalulekile, nosekuvezwe wuMcEnery benoHardie (2014), wukuthi ikhophasi ingasetshenziswa njengendlela yokwenza ucwaningo *(corpus as a research methodology),* iphinde futhi isetshenziswe njengomhlahlandlela wokuhlahlela ucwaningo *(corpus as a theoretical framework).* Lapha kulolu cwaningo, ikhophasi isetshenziswe njengendlela yokwenza ucwaningo, yaphinde futhi yasetshenziswa njengomhlahlandlela walo lolu cwaningo.

Njengoba sekutshengisiwe nguTaylor (2010), ikhophasi kanye nezifundo zocwaningozilimi kungaba yizizinda lapho khona eminye imihlahlandlela yolimi engahluma khona iphinde icutshungulwe futhi[5]. Okubalulekile lapha okumele kuqondwe, wukuthi ikhophasi njengomhlahlandlela iyahambelana nemihlahlandlela yezinhlelo zamakhompyutha *(theories of Natural Language Processing).* Okuzovela

[4] Umsebenzi ka-Taylor (2010) uveza khophasi njengomhlahlandlela.

[5] Corpus linguistics can also be a paradigm in which theories could emerge and be explicated on (Taylor 2010).

khonakulolu cwaningo wukuhambelana kwekhophasi yesiZulu kanye nezinhlelo zamakhompyutha ekucubunguleni ulimi lwesiZulu. Uma kucutshungulwa ikhophasi kusuke kucutshungulwa lona ulimi uqobo. NgokukaEgbert Larsson noBiber (2020), umhlahlandlela wekhophasi ufaka ukucutshungulwa kwayo ikhophasi. Ikhophasi yimibhalo eqoqiwe yabe isihlelwa ngohlu oluthile; le mibhalo yekhophasi iyaye icutshungulwe ngemishini yamakhompyutha[6].

Muningi umsebenzi okumele wenziwe ekuqoqweni kwekhophasi yesiZulu. Umhlahlandlela wekhophasi ungasetshenziswa futhi ekucwaningeni uhlelo lolimi lwesiZulu. Esikhathini esiningi uma abacwaningi bohlelo lolimi benza ucwaningo olimini olufana nesiZulu, bayaye bafune abantu abakhuluma lona ulimi lwesiZulu. Kepha-ke, ukuba khona kwekhophasi kuyakuveza ukuba ikhophasi uqobo lwayo ingasetshenziswa ngabacwaningi bolimi ekucwaningeni uhlelo lolimi; nomhlahlandlela wekhophasi uyahambelana nakho lokhu. Ukuba khona kwekhophasi kanye nomhlahlandela wayo kuveza izindlela ezahlukene zokucwaninga ulimi. Okunye okubalulekile okumele kuqondwe lapha wukuthi ikhophasi njengomhlahlandlela ayisetshenziswa lapho okucwaningwa ulimi khona kuphela, kepha futhi ingasetshenziswa ekufundeni kanye nasekufundiseni ulimi olufana nesiZulu.

UMcEnery kanye noHardie (2014) bathi umhlahlandlela wekhophasi uyingqikithi enkulu ekuthuthukeni komkhakha wezocwaningozilimi kanye nokuthuthuka kokusetshenziswa kwamakhompyutha ekucwaningeni ulimi.[7] UMcEnery kanye noHardie (2014) baqhuba bathi umhlahlandlela wekhophasi usuguquguquke izikhashana eziningana kusukela kudala lapho khona owawusetshenziselwa kwikhophasi yocwaningozilimi, kuze kube yimanje lapho khona ususetshenziswa kakhulu emikhakheni eminingi efana nomkhakha wezinhlelo zamakhompyutha ezisetshenziselwa ukucwaninga ulimi, umkhakha wocwaningozilimi wekhophasi, kanye nakweminye imikhakha[8]. Kulolu cwaningo-ke, umhlahlandlela wekhophasi ulawula

[6] Corpus-based studies involve the investigation of corpora, i.e. collections of (pieces of) texts that have been gathered according to specific criteria and are generally analysed automatically (Egbert, Larsson and Biber 2020).

[7] The concept of a corpus has been central to the development of linguistics, especially computational linguistics (McEnery and Hardie 2014).

[8] The concept of a corpus as a theory has evolved over time, from the early days of corpus linguistics to the present day, where corpora are widely used in

imibhalo lena evela ezibonelweni, uphinde futhi ulawule izinsizanhlelo zamakhompyutha ezisetshenzisiweyo lapha.

Izibonelo kulolu cwaningo ezihlaziywa ngaphansi komhlahlandlela wekhophasi ziveza okusha ngolimi lwesiZulu futhi zibonisa okungenziwa ngolimi lwesiZulu uma kusetshenziswa ikhophasi kanye nezinhlelo zamakhompyutha. Umhlahlandlela wekhophasi uphinde futhi ulawule ukuqoqwa kanye nokuhlelwa kwayo ikhophasi. Ngakho-ke, uma kukhona izinhlelo zokuqhubeka nokwakha ikhophasi yesiZulu, lezo zinhlelo kuyomele zilandele umhlahlandlela wekhophasi. Ukusetshenziswa komhlahlandlela wekhophasi ekucwaningeni ulimi lwesiZulu kuyosiza ukuba kubonakale okusha ngolimi lwesiZulu okukade kungabonakali ngaphambilini. Ngaphezu kwalokho, umhlahlandlela wekhophasi usiza futhi nasekwakhiweni kwalo ulimi. Uma kwakhiwa ikhophasi yolimi lwemvelo, kusuke kwakhiwa lona ulimi uqobo lwalo. Ukusetshenziswa kwekhophasi nomhlahlandlela wayo ekwakheni ulimi kwenza ukuba lolo limi lwephuse futhi luthuthuke, ludlondlobale.

Ingabe luyini uhlelo lwe-*Python* na?

Uhlelo lwe*Python* wuhlelo lwekhompyutha lokwakha ezinye izinhlelo zamakhompyutha. Izinhlelo zamakhompyutha zibunjwa noma zakhiwa ngokusebenzisa ezinye izinhlelo ezifana no*Python.* Isibonelo nje, uhlelo lokuxhuma i*Facebook* lwakhiwe kusetshenziswa izinhlelo ezifana nayo i*Python.* Zonke izinhlelo ezikwikhompyutha nezikomakhalekhukhwini zakhiwe kusetshenziswa izinhlelo zokwakha izinhlelo zamakhompyutha. NgokukaHao kanye noHo (2019: 352), uhlelo lwe*Python* wuhlelo oluthandwa kakhulu[9] futhi oselusetshenziswe ezinhlakeni eziningi zezemfundo. Siyathola ukuba nasesayensini yezilimi lolu hlelo luyasetshenziswa. Izilimi eziningi emhlabeni sezicutshungulwe, zaphinde zaphucuzeliswa ngaphansi kwalo lolu hlelo lwe*Python.* Uhlelo lwe*Python* yilo olusetshenziswe njengethuluzi lokucubungula imibhalo ekhethiweyo yesiZulu kulolu cwaningo. Ngakho-ke, lapha, kuchazwa kwenatshwe ngokugcwele nge*Python.* UMalloy noPower

many areas of research, including natural language processing, computational linguistics, and other fields (McEnery and Hardie 2014).

[9] The Python programming language is gaining tremendous popularity (Hao and Ho 2019: 352).

(2017) bachaza i*Python* njengohlelo oluthandwa kakhulu lwesimanje lokwenza izinhlelo zamakhompyutha. Ngokukavan Rossum benode Boer[10][11] (1991), uhlelo lwe*Python* "… wuhlelo oluphelele lokwakha ezinye izinhlelo zamakhompyutha". Uvan Rossum[12] kanye node Boer (1991) baqhuba bathi-ke uhlelo lwe*Python* wuhlelo ongakwazi ukwenza ngalo imisebenzi eminingi kumakhompyutha. Bathi futhi-ke i*Python* wuhlelo olungasetshenziswa ukulawula noma-ke udambisa izinkinga ezikhona ezikhethekileyo esibhekene nazo[13].

Kokunye-ke, kokumele kwaziwe, wukuthi ziningi izinhlelo zokwenza ezinye izinhlelo zamakhompyutha. Izinhlelo ezisetshenziswa kakhulu kubalwa *Perl,* i-*C,* i-*C+,* i-*C++,* i-*Java* kanye nezinye eziningana impela. UWeisser (2009) uncoma kakhulu uhlelo lwe*Perl* kanti futhi uthola okuningi kulolu hlelo okuhambisana nokuhlaziya izilimi ngaphansi kwezifundo zezilimi. UWeisser (2009) uchaza kabanzi ukuba ingafakwa kanjani i*Perl* kumakhompyutha bese iyasatshenziswa ukuhlaziya izilimi. Kodwa-ke, uma iqhathaniswa ne*Python,* i*Perl* ayikwazi ukusetshenziselwa imisebenzi eminingi, kanti futhi kukhona izinhlelo i*Perl* engenazo, ezithokozelwa kakhulu ngabasunguli bezinhlelo zamakhompyutha. Kulolu cwaningo, uhlelo lwe*Python* lukhethwe ngoba yilo lona olusetshenziswa kakhulu esikhathini samanje okwedlulla lezi ezinye izinhlelo, kanti futhi lungasetshenziselwa ukwenza imisebenzi eminingi. Ngaphezu kwalokho, kulula kakhulu ukusebenzisa i*Python* kunokusebenzisa i*Perl* noma i-*C+*.

NgokukaMalloy kanye noPower (2017), uhlelo lwe*Python* lungasebenzisana nezinye izinhlelo zokwenza amakhompyutha[14]. Lokhu kusho ukuthi ezinye izinhlelo ezindala kanye nezinye izinhlelo ezenziwe ngezinye izinhlelo zingahambelana ne*Python* yamanje. Uhlobo lwe*Python* olusetshenzisiwe ngenkathi kwenziwa lolu cwaningo i*Python 3.8.5.*

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[10] '… interpreted prototyping language' (van Rossum and de Boer 1991: 283).

[11] Lokhu kusho ukuthi uhlelo lwe*Python* wuhlelo oluphelele lokwenza izinhlelo zamakhompyutha, okusho ukuthi awuzidingi ezinye izinhlelo ezengeziwe ukuze ubumbe uhlelo lwekhompyutha.

[12] Ngumnumzane Guido van Rossum owakha izinhlelo zamakhompyutha okunguye owasungula uhlelo lwe*Python.*

[13] Mayelana nalokhu, wobona ingqikithi yocwaningo lukavan Rossum kanye node Boer, olwashicilelwa ngonyaka wezi-1991.

[14] Python has what is referred to as *backward* and *forward* mobility (Malloy and Power, 2017: 01).

Emkhakheni wamakhompyutha kanye nasemkhakheni wezesayensi yamakhompyutha izinto zinokuguquguquka ngokukhulu ukushesha. Lokhu kuguquguquka kusho ukuthi khona kusasa lokhu okusayo kungaba khona olunye uhlelo olusha lwe*Python,* noma olunye uhlelo olusha olungathandwa ngabantu olungenza yona i*Python* ukuba ingabe isasetshenziswa. Ngokuguquguquka ngokuphazima kweso kwezinhlelo emkhakheni wamakhompyutha, ocwaningweni olulandelayo, oluzokwelama lolu, kungenzeka ukuba lona luyobe selusebenzisa uhlobo olusha lwe*Python,* noma olunye uhlelo olusha oseluyobe selusetshenziswa yiningi labantu, futhi oseluyobe selusebenziseka kalula kakhulu. Ngaphezu kwalokhu, esinye isizathu esidala ukuba i*Python* ithandwe kakhulu wukuba kulula kakhulu ukuqonda ulimi olusetshenziswa kwi*Python* kanti futhi nokusebenzisa yona i*Python* kulula kakhulu[15]. I*Python*[16] wuhlelo olutholakala mahhala, kanti futhi lulawulwa luphinde luhlelwe wumphakathi wayo i*Python*[17]. NgokukaPiwek kanye noSavage (2020), ukwenza izinhlelo zamakhompyutha akubizi mali[18]. Njengoba izinhlelo zamakhompyutha kanye nokwenza izinhlelo zamakhompyutha kumahhala nje, kusho kona ukuthi lezi zinhlelo zingasetshenziswa lapho khona kuthuthukiswa, kufundwa, kufundiswa noma kuhlaziywa ulimi lwesiZulu.

Emuva kweminyakana eminingana uhlelo lwe*Python* lwasungulwa, kukhona izinsizanhlelo eziqhakambileyo, ezihambelana nayo i*Python,* okuyizona ezihlabahlosile ekuhlaziyeni ulimi. Uhlelo lwe*Python* luhambelana nezinsizanhlelo ezihlabahlosileyo ezifana ne*Natural Language Toolkit (NLP)* kanye ne*Tkinter.* ITkinter iyona esetshenziswayo uma kwakhiwa izinkundla[19]

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[15] Python’s elegant, and not overly cryptic, syntax, emphasizes support for common programming methodology and promotes code readability and thus maintainability (Hao and Ho 2019: 348).

[16] Ubukhondlakhondla bohlelo lwe*Python* bufakazelwa futhi nguCai benoLangtangen *et al.,* (2005).

[17] The Python programming language is open-source and it is maintained by the Python community (Hao and Ho 2019: 352).

[18] Therefore, in this case, programming is an open-source concept (Piwek and Savage 2020).

[19] Igama elithi ‘inkundla’ yigama eliyitemu lesiZulu elisho i*Graphical User Interface (GUI).* Leli temu livela emsebenzi kaKeet noBarbour (2014). UKeet

noma oBhalabuso[20] bezinhlelo zamakhompyutha nomakhalekhukhwini. Kulolu cwaningo kusetshenziswe ama*regular expressions* ukuhlaziya izinhlamvu, amagama, imisho, imibhalo kanye nekhophasi yesiZulu. Njengoba sekubaluliwe esingenisweni salolu cwaningo ukuthi izinhlelo ze*Python* zokuhlaziya izilimi zemvelo kazicwasi ngokolimi. Ngakho-ke, izinsizahlelo zama*regular expressions*, ezingaphansi kwe*Python,* zingahlaziya nanoma yiluphi ulimi lwabantu. Lapha, kusetshenziswe izinsizanhlelo zama*regular expressions* ukuhlaziya imibhalo yesiZulu.

Kwi*Python* kukhona insizanhlelo ebizwa ngokuthiwa yi*Natural Language Toolkit (NLTK).* Le nsizanhlelo iwuhlelo oluhle impela ekuhlaziyweni kolimi olulotshiwe. Kepha-ke, le nsizanhlelo ayihambelani kahle nolimi lwesiZulu. Enye insizanhlelo ehambelana ne*Python* yi*Jupyter Notebook*[21]. Izilimi zabantu zinemithetho ephawulekayo. Amakhompyutha kumele ayifunde le mithetho ukuze azokwazi ukulufunda kanye nokuluphimisa ulimi lwabantu. Amakhompyutha kumele ayihangule yonke le mithetho bese eluqonda ulimi. Indlela amakhompyutha ahangula ngayo ulimi wukuba anikezwe lona ulimi uqobo lwalo. Amakhompyutha akwazi ukwamukela ulimi olusesimweni sekhophasi. Into yokuqala ngqa okumele yenziwe uma kufundiswa amakhompyutha ulimi wukuba kuqoqwe ikhophasi yolimi. Emuva kwalokho sekungasetshenziswa izinhlelo ezifana no*Python* ukubalulela amakhompyutha imiyalelo kanye nemithetho yolimi. Emuva kwalokho-ke, amakhompyutha azobe eseqala ukuluqonda ulimi.

Isilingo Socwaningo Kanye Nemiphumela Yalo Ucwaningo

Ukusebenzisa Izinhlelo Ezikhethiweyo Zamaregular Expressions Ukuhlahlela Nokuhlaziya Imibhalo YesiZulu

I*Jupyter Notebook* insizanhlelo ehambelana nohlelo lwe*Python*

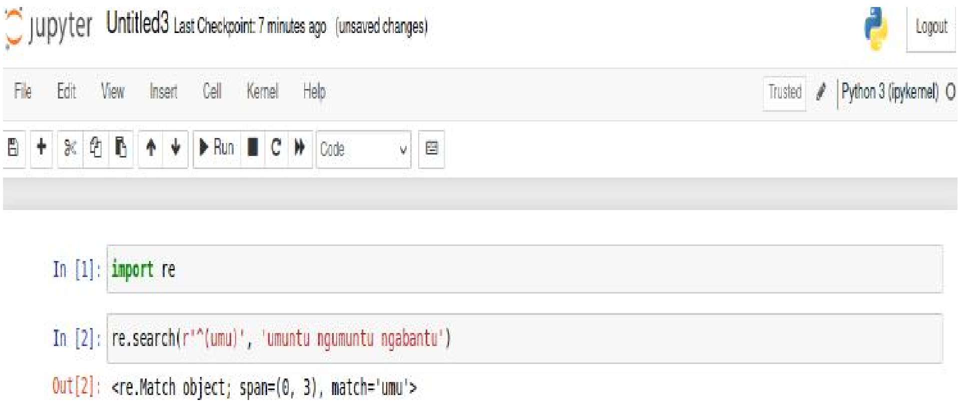
---

noBarbour (2014) bona leli temu balithathela esizindeni solwazi somnyango wezamaciko kanye namasiko waseNingizimu Afrika, wonyaka wezi-2005.

[20] UBhalabuso yitemu lesiZulu elisungulwe kulolu cwaningo elichaza i*Graphical User Interface (GUI).* Itemu elithi 'inkundla' lingaba nezinye izincazelo ezengeziwe esiZulwini; kepha itemu elithi 'uBhalabuso' lona linencazelo eyodwa kuphela ye-*GUI*.

[21] Insizanhlelo ye*Python* okuyaye kulotshelwe kuyo izinhlelo yi*IDLE*. Kepha lapha kulolu cwaningo izinhlelo zilotshelwe kwinsizanhlelo i*Jupyter Notebook.*

engasetshenziselwa ukuloba izinhlelo zamakhompyutha. Lapha kulolu cwaningo, i*Jupyter Notebook* isetshenziselwe ukuloba izinhlelo ezithungatha ubunjalo bemithetho yolimi lwesiZulu. I*Jupyter Notebook* ingasetshenziswa ngendlela efanayo ne*IDLE*. I-*IDLE* enye insizanhlelo ehambelana nohlelo lwe*Python*. Ama*regular expressions*[22] asetshenziselwa ukuthungatha imithetho ephindaphindikeyo yolimi. Ama*regular expressions* angalotshelwa kwinsizanhlelo i*Jupyter Notebook*. Ekwenzeni lolu cwaningo kufakwe i*Jupyter Notebook* kwikhompyutha kusetshenziswa uhlelo lo-*Ubuntu OS*. I*Jupyter Notebook* itholakala kanti futhi isetshenziswa mahhala. Kulesi sibonelo sohlelo esilotshelwe kwi*Jupyter Notebook*, kuyavela ukuba ingasetshenziswa kanjani i*Jupyter Notebook* kanye nohlelo olulotshwe kuyo ukuhlaziya kanye nokuhlahlela imibhalo yolimi lwesiZulu. Okunye okubalulekile wukuba i*Jupyter Notebook* lena wusiba olusetshenziselwa ukuloba izinhlelo zamakhompyutha olungacwasi ngokolimi. Okusho ukuthi-ke, i*Jupyter Notebook* ingasetshenziselwa ukuloba izinhlelo ezihlaziya yinanoma yiluphi ulimi olusetshenziswa ngabantu.



Isibonelo sokuqala: ukutonyulwa kwesakhiqho esikhethiweyo emshweni wesiZulu

[22] Ama*regular expressions* amelwe wu-*re* lo ovela kuBhalabuso lwe*Jupyter Notebook.*

Uhlelo lokuqala olulotshiwe ngaphezulu lapha lutshengisa ukuba lungatonyulwa kanjani uhlamvana lwegama olukhethiweyo. Ukuze kufezekiswe lo myalelo wokutomula isakhiqho u-*umu*, kuyomele kuqalwe kubizwe insizanhelo i*regular expression*[23] evela njengo-*re* ezibonelweni. Lokhu kubonakala esibonelweni sohlelo lokuqala esilotshiwe. Ukusetshenziswa kwensizanhlelo u-*re* kuvela nakwezinye futhi izibonelo lapha kulolu cwaningo.

Emgqeni wesibili, esibonelweni sokuqala lapha ngaphezulu, kunemiyalelo kanye nomusho obhaliwe. Umyalelo wohlelo ufezekiswe ngaphansi komugqa wesibili. Umugqa ongaphansi komugqa wesibili lapho okuvela khona umphumela womyalelo wu-*out [2]*. Umyalelo esibonelweni sokuqala uthi, tomula isiphongozo u-*umu* ebizweni elisemshweni. Esibonelweni sokuqala, lesi siphongozo yiso esokuqala enhlokweni yomusho. Okubonakalayo-ke, wukuba lo myalelo ufezekisekile impela ngokweqiniso.

```
In [1]: import re

In [2]: re.search(r'^(umu)', 'umuntu ngumuntu ngabantu')
Out[2]: <re.Match object; span=(0, 3), match='umu'>

In [3]: re.search(r'(ntu)$', 'umuntu ngumuntu ngabantu')
Out[3]: <re.Match object; span=(21, 24), match='ntu'>
```

Isibonelo sesibili: ukutonyulwa kwesakhiqho esikhethiweyo emshweni wesiZulu

Esibonelweni sesibili sohlelo esilotshiweyo lapha ngaphezulu kutshengiswa ukutonyulwa kwesakhiqho esikhethiweyo emshweni wesiZulu. Lesi sakhi siyisiqu esivela ekugcineni kwamabizo emshweni. Umyalelo lapha ulotshwe emgqeni wesithathu u-*in [3]*. Umyalelo ngu-*re.search (r'(ntu)$')* okuyiwo osebenza umsebenzi wokuthungatha kanye nokutomula isiqu u-*ntu*. Njengoba kubonakala esibonelweni sesibili, umyalelo ufezekisiwe wuhlelo. Umphumela womyalelo uvela ngaphansi komugqa wesithathu u-*out [3]*.

[23] Ukuze kubizwe insizanhlelo yama-*regular expressions* ohlelweni kumele kusetshenziswe umyalelo othi: *import re*.

Umyalelo olandelayo, esibonelweni sesithathu, ungaveza ukuphindaphindeka kwezakhiqho emabizweni asemibhalweni yolimi lwesiZulu.

```
In [5]: re.search(r'(hamba){2}', 'umthakathi uyahambahamba ebusuku')

Out[5]: <re.Match object; span=(14, 24), match='hambahamba'>
```

Isibonelo sesithathu: ukutonyulwa kwesakhiqho esiphindaphindekile emshweni wesiZulu

Esibonelweni sesithathu, umyalelo wukuba kutshengiswe isakhiqho esiphindaphindikayo sesiZulu u-*hamba*[24].

Emgqeni wesihlanu, lesi sakhi siphindaphindeke kabili kuphela. Umyalelo ufezekile-ke lapha, njengoba kubonakala ngaphansi komugqa wesihlanu. Uhlelo luwuqondile umyalelo, lawenza, lawubuyisa. Ngale nsizanhlelo i-*re.search* yama*regular expression*[25] kungabhekwa, kokunye, ukuthi kungatonyulwa kanjani 'amagama' okanye izinhlamvana zamagama esiZulu. I-*re.search* ingasiza ukuba kuthungathwe ubunjalo bezinhlamvu zamagama esiZulu. Ngaphezu kwalokho, uma kukhona okuyiganyana okuthungathwayo embhalweni noma ekhophasini yesiZulu, kungasetshenziswa i-*re.search* ukuba kutholwe lezo zinhlamvana, noma lawo malunga, noma lawo maganyana kanye nemishwana edingakalayo.

Esibonelweni sesine esilotshiweyo lapha ngaphezulu, ama*regular expressions* abizwe emgqeni wokuqala. Emgqeni wesibili, kufakwe ikhophasi yesiZulu okuwumbhalo wesiZulu. Emgqeni wesithathu, insizanhlelo i*findall* isetshenzisiwe ukuze ihlele 'amagama'[26] akwikhophasi. I-*re.findall* iwahlele

---

[24] Igama elithi 'hamba' liyisenzo ngokuphelele. Kepha njengoba livela lapha kulo musho liphindaphindekile nje, ingxenye yalo ithatha indima yesakhi emshwaneni othi 'uyahambahamba.'

[25] I-*search* yama*regular expressions* ivela njenge-*'re.search'* esibonelweni sokuqala nesesibili kanye nesesikhombisa.

[26] Igama elithi 'igama' lisetshenziswe ngokukhulu ukucophelela kulolu cwaningo. Isizathu salokhu ngukuthi okubukeka kuyigama kungenzeka kube wumusho noma wumshwana esiZulwini. Incazelo yokuba liyini igama esiZulwini ingatholakala kuNyembezi (1986: 44-64).

ngohlu wonke amagama akwikhophasi. Uhlu lwamagama lubonakala ngaphansi komugqa wesithathu. Lokhu kusho ukuthi umyalelo ufezekile. Ngale nsizanhlelo i-*re.findall*, sikwazi ukuwola wonke amagama akwikhophasi siwahlele ngendlela ehlelekileyo.

```
In [1]: import re

In [2]:
        kusuka kosopolitiki, abenkolo kanye namagumgedlela zasusa amehlo kulokho okuhle okuwavelelayo nokuyinqabakutholwa.'''

In [3]: re.findall(r'\b[a-z]{2,15}\b', text)

Out[3]: ['ungungoti',
         'wepolitiki',
         'nepolitiki',
         'yezomnotho',
         'ozoqinisa',
         'udonga',
         'lwasemuva',
         'mamagama',
         'yinyosi',
         'lapho',
         'yeba',
         'ithi',
         'ehlasela',
         'ngothando',
         'zibonakele',
         'kuleli',
         'sonto',
         'yiningi',
         'ngesikhathi',
         'ehola',
         'ithimba',
         'osomlando',
         'nosomabhizinisi',
         'njengengxenye',
         'yemigubho',
         'yesikhumbuzo',
         'seminyaka',
```

Isibonelo sesine: ukusetshenziswa kwensiza u-*re.findall* emibhalweni yesiZulu

I-*re.findall* ikwazi ukuthola yonke into ekwikhophasi, yonke into ewumbhalo, bese iyiqoqela ndawonye. Lesi nje yisibonelo. Kuningi okunye i-*re.findall* engasetshenziselwa kukho emibhalweni yesiZulu.

Omunye umsebenzi we-*re.findall* wukuba itomule lelo gama elithungathwayo ekhophasini. Esibonelweni sesihlanu sohlelo esilotshiwe lapha ngezansi, igama elithi 'Zuma' litonyulwe embhalweni ovela emgqeni wesibili. Leli gama livela neziqalo zalo ngaphansi komugqa wesithathu kanye

nangaphansi komugqa wesihlanu. Okunye esikubonayo esibonelweni sesihlanu, emgqeni wesine kanye nasemgqeni wesithupha, wukuba ayikho imiphumela yegama elithi ANC. Nakuba likhona leli gama embhalweni, kepha uhlelo luyala ukubuyisa igama. Ngabe kusho ukuthini lokhu na? Khumbula ukuthi igama elikhethiweyo lapha libuya nesiphongozo salo. Igama elithi ANC alinaso isiphongozo sendalo olimini lwesiZulu. Igama elithi ANC liqala ngonkamisa, ngakho-ke, lehlukaniswe wudwi esiphongozweni esingunkamisa sesiZulu. Lo dwi owehlukanisa onkamisa yiwo odala ukuba uhlelo lungambuyisi u-ANC. Njengoba sazi umthetho wolimi lwesiZulu ukuba onkamisa abalandelani neze kulolu limi.

```
In [1]: import re

In [2]: text = '''OWAYENGUMENGAMELI wakuleli uMnuz Jacob Zuma usenxenxe abakuleli ukuthi basukume bavote njengoba kuzoba nokh
        Inhlangano engenzi nzuzo kaZuma, iJG Zuma Foundation, izolo ifake i-video yakhe ezinkundleni zokuxhumana egquqguzela
        UZuma uthe kumthintile enhlizweni ukuzwa ukuthi kunabantu asebedube ukuvota ngenxa yezizathu ezithile.
        "Asisukumeni sonke sivote, sivotele ikakhulukazi lo mbutho owaletha inkululeko, i-ANC. Kubalulekile ukuthi lokho sikw
            BREAKING NEWS
            H.E President Zuma gives a clear line of march. pic.twitter.com/gSfWjoIcmd
            — JGZuma Foundation (Official) (@JGZ_Foundation) October 5, 2021
        UZuma ubekhuluma okokuqala nabantu bakuleli selokhe aphuma ngoshwele wokugula ejele lase-Estcour lapho aqale khona is
        Ngenyanga edlule inhlangano yakhe imemezele ukuthi uzokwamukelwa ngenkonzo yomkhuleko ngo-Okthoba 14 lapho kumenywe k

In [3]: re.findall(r'\wZuma', text)
Out[3]: ['aZuma', 'UZuma', 'uZuma', 'GZuma', 'UZuma']

In [4]: re.findall(r'\wANC', text)
Out[4]: []

In [5]: re.findall(r'\w+Zuma', text)
Out[5]: ['kaZuma', 'UZuma', 'uZuma', 'JGZuma', 'UZuma']

In [6]: re.findall(r'\w+ANC', text)
Out[6]: []
```

Isibonelo sesihlanu: ukusetshenziswa kwensiza u-*re.findall* ukutomula 'igama' kanye nesakhiqho salo

Esibonelweni sesithupha, emgqeni wokuqala, emagameni atholakala emshweni, kubalwa igama elithi: *isilo*, *uNomthebe* kanye negama elithi *wethu*. La magama-ke, ayathungathwa emshweni bese eyatonyulwa kusetshenziswa insizanhlelo i*search* yama*regular expressions*. Njengoba la magama ekhona emshweni, abe eseyabuyiswa wuhlelo. Qaphela-ke ukuthi igama elithi *ilanga* emgqeni wesine alizange libuyiswe wuhlelo. Isizathu esidala lokhu ukuba kwenzeke, yingoba leli gama vele alikho emshweni. Uhlelo lubuyisa kuphela amagama kanye nezakhi zamagama ezikhona embhalweni.

```
In [1]: import re

        sentence = "uNomthebe wethu osekhotheme. Isilo sakwaDlamahlahla"

In [2]: re.search ("Isilo", sentence)
Out[2]: <re.Match object; span=(29, 34), match='Isilo'>

In [3]: re.search ("uNomthebe", sentence)
Out[3]: <re.Match object; span=(0, 9), match='uNomthebe'>

In [4]: re.search ("ilanga", sentence)

In [5]: re.search ("wethu", sentence)
Out[5]: <re.Match object; span=(10, 15), match='wethu'>
```

Isibonelo sesithupha: ukusetshenziswa kwensiza i-*re.search* ukuthungatha kanye nokutomula 'igama' olidingakalayo embhalweni.

Kubukeka sengathi awukho umkhawulo wamagama esingawufaka kwikhophasi. Esibonelweni sesikhombisa, 'amagama' ayikhulu neshumi atholakala embhalweni ofakiweyo. Igama elithungathiwe lapha yigama elithi *uShaka*.

```
In [1]: import re

        sentence = "UDlungwane kaNdaba Ilembe eleq' amanye amalembe ngokukhalipha UNodum'ehlezi kaMenzi uSishak' asishayeki -

In [2]: re.search("uShaka", sentence)
Out[2]: <re.Match object; span=(129, 135), match='uShaka'>
```

Isibonelo sesikhombisa: ukuthungatha amagama akhethiweyo kwikhophasi yesiZulu enamagama ayikhulu neshumi.

Ekuhlaziyeni umbhalo oyikhophasi yesiZulu, kukhona enye indlela engasetshenziswa ukuba umbhalo osekhophasini uvulwe noma ufundwe ngqo usesigudlweni[27] sawo. Lokhu kungenziwa kusetshenziswa uhlelo oluyinsizakusebenza u-*open* oluyingxenye yohlelo i*Python*. Lokhu-ke, kungavula izigudlo ezinkulu zekhophasi ukuba kucwaningwe imibhalo ngendlela elungileyo kanye nangendlela eyonga isikhathi. Ukuvulwa kwekho-phasi kusetshenziswa u-*open* kuzovela kahle esibonelweni seshumi nanye.

[27] Igama elithi 'isigudlo' kulolu cwaningo lisho ukuthi *'file'*. Ukuhunyushwa kwegama elithi *'file'* kusesichazamazwini sangonyaka wezi-1969 sikaDent kanye noNyembezi, ekhasini lama-92.

Uhlelo lwama*regular expressions* lukwazi futhi ukushintsha izinhlamvana zamagama kanye namagama uqobo lwawo. Singasebenzisa insizanhlelo i-*re.sub* ukuguquguqula izinhlamvana zamagama kanye namagama emibhalweni yesiZulu. Isibonelo sesishiyagalombili sitshengisa ukuba i-*re.sub* ingasetshenziswa kanjani emibhalweni yesiZulu.

```
In [2]: import re

In [3]: string = """UShaka kaSenzangakhona wayeyinkosi yaseMashobeni"""

In [4]: print (re.sub('UShaka', 'ILembe', string))

        ILembe kaSenzangakhona wayeyinkosi yaseMashobeni

In [5]: print (re.sub('UShaka kaSenzangakhona wayeyinkosi yaseMashobeni', 'ILembe likaSenzangakhona laliyinkosi', string))

        ILembe likaSenzangakhona laliyinkosi
```

Isibonelo sesishiyagalombili: ukusetshenziswa kwensizanhlelo i-*re.sub* embhalweni wesiZulu

Esibonelweni sohlelo sesishiyagalombili esilotshiweyo lapha ngaphezulu, igama elithi *'uShaka'* liguquliwe kwaba yigama elithi *'iLembe.'* Lokho okuguqulwe wuhlelo lapha kuvela ngaphansi komusho wesine. Ngensizanhlelo yokushintsha amagama i-*re.sub function*, singashintsha futhi izakhi okanye izinhlamvana zawo amagama. Emgqeni wesihlanu kushintshwe izivumelwano zebizo emshweni. Lapha kulo mugqa kujotshelelwe ngezivumelwano ezivumelana nebizo elithi, *'iLembe.'* Uhlelo lube selubuyisa-ke konke lokhu ngaphansi komugqa wesihlanu. Ibizo elithi, *'iLembe'* yilo elibiza sakuphoqa uhlobo lwezivumelwano ezizoba semshweni.

Inhlosongqangi yama*regular expression* wukuthungatha kanye nokuthola imithetho yokupela kanye nemithetho yohlelo yolimi. Amakhompyutha afunda imithetho yolimi ngokusetshenziswa kwama*regular expressions.* Ngokwama*regular expressions*, uma amakhompyutha eseyazi imithetho yokupela kanye nemithetho yohlelo yolimi, azobe esekwazi ukulusebenzisa ulimi. Isibonelo sesishiyagalolunye sinamagama ayikhulu neshumi. Insizanhlelo i*patter=re.compile* isetshenzisiwe ukuba ibheke futhi itomule uhlamvana lwegama u*'lem'*[28] embhalweni osohlelweni. Insizanhlelo

[28] Lapha kungenzeka ukuba u-*'lem'* uqhamuka egameni elithi *'iLembe'* elisembhalweni ohlaziywayo.

imtholile u*'lem'* yabe isimbuyisa ngaphansi komugqa wesihlanu. Buka isibonelo seshumi uqaphele ukuba u*'aei'* awuzange ubuyiswe wuhlelo[29]. Ngaphansi komugqa wesihlanu awukho umphumela. Lapha-ke, sekungenziwa isiphetho mayelana nengxenyana yomthetho yolimi lwesiZulu ukuba ukupela ngokulandela u-*'aei'* akuvumelekile kulolu limi.

```
In [1]: import re

In [2]: test_string = 'UDlungwane kaNdaba Ilembe eleq' amanye amalembe ngokukhalipha UNodum'ehlezi kaMenzi uSishak' asishayek

In [3]: pattern = re.compile(r"lem")

In [4]: matches = pattern.finditer(test_string)

In [5]: for match in matches:
            print(match)

        <re.Match object; span=(20, 23), match='lem'>
        <re.Match object; span=(42, 45), match='lem'>
```

Isibonelo sesishiyagalolunye: ukusetshenziswa kwensizanhlelo i*patter=re.compile* embhalweni wesiZulu

```
In [1]: import re

In [2]: test_string = 'UDlungwane kaNdaba Ilembe eleq' amanye amalembe ngokukhalipha UNodum'ehlezi kaMenzi uSishak' asishayek

In [3]: pattern = re.compile(r"aei")

In [4]: matches = pattern.finditer(test_string)

In [5]: for match in matches:
            print(match)

In [ ]:
```

[29] Onkamisa abalandelani esiZulwini, kepha bayalumbana. Ngokulekelelwa yikhophasi, izinhlelo zamakhompyutha ziyakwazi ukuthi zifakazele ubunjalo bemithetho yolimi lwesiZulu. Lezi zinhlelo zifakazela imithetho ekhona, kanti futhi zingasiza ekulondolozeni le mithetho. Lezi ezinye nje izibonelo ezitshengisa ukusetshenziswa kwezinsizanhlelo zamakhompyutha ukuhlaziya ulimi lwesiZulu.

Isibonelo seshumi: ukusetshenziswa kwensizanhlelo i*patter=re.compile* embhalweni wesiZulu ukuthungatha ubukhona kanye nokungabibikho kwezakhi ezithile zamagama

Ukusebenzisa insizanhlelo u-'infile' kanye no-'open' ukuvula isigudlo esikhulu sekhophasi yesiZulu

Ngezinye izinhlelo zamakhompyutha singakwazi ukuvula izigudlo ezinkulu zekhophasi. Esibonelweni seshumi nanye esilandelayo kuvela uhlelo olulotshiwe lokuvula isigudlo sekhophasi ekwikhompyutha.

Lolu hlelo lokuvula ikhophasi luhlabahlosile impela. Lungavula ikhophasi yanoma yibuphi ubukhulu. Ubukhulu bekhophasi evulwe esibonelweni seshumi nanye bungu 40.6 kb[30]. Ukusuka lapha-ke, ikhophasi isingahlaziywa, icutshungulwe. Isibonelo sohlelo esilotshiwe seshumi nanye senza ukuba izinhlelo zokuhlaziya ikhophasi ezifana no*wordsmith tools*,o*sketch engine* kanye no-*antconc* zingabe zisaba naso isidingo sokuthi zisetshenziswe esiZulwini[31]. Umbhalo wekhophasi osesibonelweni seshumi nanye uvela ephephandabeni iLanga. Le khophasi isesimweni sesigudlo esiyi-*txt*[32]. Esibonelweni seshumi nanye, ikhophasi ibizwe ngaphansi kuka*filename,* yabe isivulwa ku-*infile.* Insiza u*lines* iphoqelela ukuba ikhophasi ivele isesimweni semisho. Izinombolo ku*lines* zisho ukuthi ubukhulu obungakanani bekhophasi okumele buvelwe. Ngale ndlela-ke, kuba lula kakhulu ukuhlaziya ikhophasi, kanti futhi konga isikhathi. Izinhlelo ze*Python* zokuhlaziya ikhophasi zitholakala mahhala[33].

---

[30] U-*kb* lapha umele u*kilobytes.*

[31] Kahle hle lezi zinhlelo azidalelwanga ukuba zihlaziye ikhophasi yesiZulu – yize noma namhlanje zisetshenziselwa ukuhlaziya ikhophasi yanoma yiluphi ulimi lwemvelo. OBhalabuso balezi zinhlelo balotshwe ngolimi lwesiNgisi. Kudingeka ukuba kwakhiwe izinhlelo zokuhlaziya ikhophasi yesiZulu, ezinoBhalabuso abalotshwe ngolimi lwesiZulu.

[32] I-*txt* wuhlobo lwesigudlo esilula, esinemibhalo kuphela, esingaxutshwe nalutho olunye. I-*txt* ihambelana kahle kakhulu nezinhlelo zamakhompyutha. Isigudlo se-*txt* siyinsizanhlelo ngokwaso naso.

[33] Igama elithi 'mahhala' lapha lisho ukuthi akukhokhwa mali uma kusetshenziswa i*Python*, kanti futhi ayikho nemithetho evimbela ukusetshenziswa kwayo i*Python.*

```
>>> #iphephandaba ilanga
>>> filename = "///home/percival/Desktop/zuluilanga00895.txt"
>>> infile = open(filename, 'r')
>>> lines = infile.readlines()
>>> lines[0:30]
['WIN DOUBLE TICKETS!!! \n', '\n', 'LIKUTHATHA LIKUBEKE \n', '\n', 'SEPTEMBER 18
, 2016 \n', '\n', 'PRICE:R3.50 INcL VAT \n', '\n', 'KWAZULU-NATAL & E/CAPE \n',
'\n', '\n', '\n', '\n', '\n', 'ILANGA LANGESONTO SEPTEMBER\n', 'Ezindala \n', '\
n', 'ndida ngethimba eSilo emanyuvesi \n', 'K. \n', 'eZOMPHAKATHI: Lizolwa nezin
xushunxushu \n', ' \n', 'VUSI MKHIZE DOSKHOSIPHI MTHEMBU \n', 'NKOMBANKOMBANE ng
ethimba elisungulwe yiSilo samaBandla iNkosi uGoodwill Zwelithini kaBhekuzulu \n
', 'elimenyezelwe eMkhosini woMhlanga ngeledlule okuthiwa Ii. zolekelela ukulwa
nezinxushunxushu emanyuvesi uma kudingeka. \n', 'ISilo ngesikhathi sethula inkul
uma yaso phambi kwenqwaba yezintombi ezinkundleni zemidlalo eNyokeni KwaNongoma
ebezisuka ezindaweni ezahlukene sithe, kuyinto embi ukucekelwa ngomlilo kwempahl
a nezimoto okwenzeka \n', 'emanyuvesi akuleli. \n', 'Sikhale nangabazali babafun
di abashiyela konke emaphoyiseni nakuhulumeni lima izingane zabo zivuka umbhejaz
ane zishisa ifupahla yesikole neyezikhungo eziphakeme. Sithe abazali bathule bat
hini uma bebona izingane zabo zicekela phansi ngomlilo impahla. \n', 'Sibuze nok
uthi uma zilokhu ziqhubeka lezi zigameko zokucekelwa phansi ngomlilo kwalezi zik
hungo abantu baseNingizimu Afrika bayozikhombisani \n', '\n', 'UVO LWAKHO: \n']
>>> |
```

Isibonelo seshumi nanye: ukusetshenziswa kwezinsizanhlelo ezivula ikhophasi ebekwe kwikhompyutha

Isibonelo sohlelo seshumi nambili esilotshiwe lapha sitshengisa ukuba singayivula kanjani ikhophasi ekwisizindalwazi[34].

```
In [1]: from textblob import TextBlob
In [2]: from newspaper import Article
In [3]: url = 'https://zu.wikipedia.org/wiki/Shaka'
In [4]: article = Article(url)
In [5]: article.download()
In [6]: text = article.text
In [7]: print(text)
```

Isibonelo seshumi nambili: ukusetshenziswa kwezinsizanhlelo ezivula ikhophasi ekwisizindalwazi

[34] NgokukaKeet noBarbour (2014), itemu lesiZulu elithi 'isizinda solwazi,' okanye 'isizindalwazi' lisho ukuthi *'internet.'*

Umzamo wokusebenzisa i-'Natural Language Toolkit (NLTK)' ekuhlaziyeni umbhalo wesiZulu

I-*NLTK* enye insizanhlelo ehambelana ne*Python* yokuhlaziya ikhophasi. Lezi zinhlelo ezisetshenziswe lapha ngaphezulu ocwaningweni kazicwasi neze ngokolimi, okusho ukuthi zingasetshenziswa kunanoma yiluphi ulimi lwemvelo lwabantu. Insizanhlelo i-*NLTK* ifika ifakwe ikhophasi yayo. Ikhophasi efika kanye ne-*NLTK* iyaye ibe solimini lwesiNgisi[35]. IsiNgisi ngale ndlela siba wulimi olusetshenziselwa ukufunda kanye nokufundisa ezinye izilimi. Isibonelo seshumi nantathu sibonisa umzamo wokusebenzisa i-*NLTK* ukuhlaziya umbhalo wesiZulu.

Esibonelweni seshumi nantathu, insizanhlelo i-*NLTK* iyingxenye yohlelo lokuhlaziya umbhalo wesiZulu. Kodwa-ke, kubonakala sengathi i-*NLTK* ayikho into eyenzayo embhalweni wesiZulu. Yize noma kuno-*NLTK* ohlelweni olulotshiwe, uhlelo lona luyaqhubeka lufezekisa imiyalelo. I-*re* emgqeni wesibili idonsa umbhalo osemgqeni wokuqala, bese iwukhiphela ngaphansi komugqa wesithathu. Uhlelo olulotshiwe emgqeni wesine lusebenza ukususa izikhala ezimhlophe eziba phakathi namagama emibhalweni.

```
In [1]: article_text="UDlungwane kaNdaba Ilembe eleq' amanye amalembe ngokukhalipha UNodum'ehlezi kaMenzi uSishak' asishayeki

In [2]: import re
        import nltk

In [3]: article_text

Out[3]: 'UDlungwane kaNdaba Ilembe eleq' amanye amalembe ngokukhalipha UNodum'ehlezi kaMenzi uSishak' asishayeki - umtakaSen
        gakhona Bath' uShaka kayikubusa akaykuba Nkosi Kanti kulaph' ezakunethezeka khona. Umlilo wothathe kaMjokwane Umlilo
        wothathe ubuhanguhangu Oshis' zikhova eziseDlebe Kwaye kwasha neziseMabedlana. Bayethe boGambushe Nani boFaku Nize n
        ingamthinti umtakaNdaba Ngoba ningathi niyamthinta Kobe nithint' uPhunga Nathint' uMageba. UNdab' ocaba ngomkhonto A
        many' amakhos' ecaba ngamazembe. UGasane, kade lubagasela Lugasel' imizi yamadoda Lugasel' uPhungashe ezalwa kwaButh
        elezi Lugasel' uSondaba woMthand' ehlez' ebandla Lugasel' uMangwane eNgonyameni Lugasel' uFaku eMaMpondweni Lugasel'
        uGambushe eMaMpondweni. Inkonyane kaNdaba Eth' isadl' ezinye, yadl' ezinye Yath' isadl' ezinye, yadl' ezinye Eth' is
        adl' ezinye, yadl' ezinye Yath' isadl' ezinye, yadl' ezinye Eth' isadl' ezinye, yadl' ezinye. Wena weNdlovu! Bayet
        e!'

In [4]: article_text = re.sub('[^a-zA-Z]', '', article_text)
        article_text

Out[4]: 'UDlungwanekaNdabaIlembeeleqamanyeamalembengokukhaliphaUNodumehlezikaMenziuSishakasishayekiumtakaSengakhonaBathuShak
        akayikubusaakaykubaNkosiKantikulaphezakunethezekakhonaUmlilowothathekaMjokwaneUmlilowothatheubuhanguhanguOshiszikhov
        aezziseDlebeKwayekwashanezziseMabedlanaBayetheboGambusheNaniboFakuNizeningamthintiumtakaNdabaNgobaningathiniyamthintaK
        obenithintuPhungaNathintuMagebaUNdabocabangomkhontoAmanyamakhosecabangamazembeUGasanekadelubagaselaLugaselimiziyamad
        odaLugaseluPhungasheezalwakwaButheleziLugaseluSondabawoMthandehlezebandlaLugaseluMangwaneeNgonyameniLugaseluFakueMaM
        pondweniLugaseluGambusheeMaMpondweniInkonyanekaNdabaEthisadlezinyeyadlezinyeYathisadlezinyeyadlezinyeEthisadlezinyey
        adlezinyeYathisadlezinyeyadlezinyeEthisadlezinyeyadlezinyeWenaweNdlovuBayete'
```

Isibonelo seshumi nantathu: umzamo wokusebenzisa i-*NLTK* esiZulwini

[35] Ziyaye zibe khona nezinye izilimi ezitholakala kwi-NLTK. Kodwa isiZulu asiyiyo ingxenye yezilimi ezitholakala kwi-NLTK.

Yize noma kunjalo, okuvelayo lapha wukuthi i-*NLTK* icwasa ngokolimi. Izingxenye eziyingqikithi kwi-*NLTK*, ikakhulukazi ikhophasi yayo, zivuna kakhulu ulimi lwesiNgisi. I-*NLTK* ikwazi ukuguquguqula amagama kuvele imisuka yawo – kodwa ikwazi ukukwenza lokhu olimini lwesiNgisi, hhayi olimi lwesiZulu. Indlela yokulungisa lesi simo wukuba kufakwe ikhophasi yesiZulu kwinsizanhlelo i-*NLTK*[36]. Isibonelo seshumi nane sibonisa umyalezo obuyiswe wuhlelo olulotshiwe lapho khona umzamo wokuhlela amagama esiZulu ngokwemisuka yawo uphunzile.

```
In [6]: sentence_list = nltk.sent_tokenize(article_text)
        sentence_list

---------------------------------------------------------------------------
LookupError                               Traceback (most recent call last)
/tmp/ipykernel_2598/3591929544.py in <module>
----> 1 sentence_list = nltk.sent_tokenize(article_text)
      2 sentence_list

~/.local/lib/python3.8/site-packages/nltk/tokenize/__init__.py in sent_tokenize(text, language)
    104     :param language: the model name in the Punkt corpus
    105     """
--> 106     tokenizer = load(f"tokenizers/punkt/{language}.pickle")
    107     return tokenizer.tokenize(text)
    108

~/.local/lib/python3.8/site-packages/nltk/data.py in load(resource_url, format, cache, verbose, logic_parser, fstruc
t_reader, encoding)
    748
    749     # Load the resource.
--> 750     opened_resource = _open(resource_url)
    751
    752     if format == "raw":

~/.local/lib/python3.8/site-packages/nltk/data.py in _open(resource_url)
    874
    875     if protocol is None or protocol.lower() == "nltk":
--> 876         return find(path_, path + [""]).open()
    877     elif protocol.lower() == "file":
    878         # urllib might not use mode='rb', so handle this one ourselves:

~/.local/lib/python3.8/site-packages/nltk/data.py in find(resource_name, paths)
    581     sep = "*" * 70
    582     resource_not_found = f"\n{sep}\n{msg}\n{sep}\n"
--> 583     raise LookupError(resource_not_found)
    584
    585

LookupError:
**********************************************************************
  Resource punkt not found.
  Please use the NLTK Downloader to obtain the resource:
```

Isibonelo seshumi nane: umzamo ophunzileyo wokuhlela amagama esiZulu ngokwemisuka yawo.

Ukucubungula kanye nokubuyekeza imiphumela

Izinhlelo zamakhompyutha zakhiwa yezinye izinhlelo zamakhompyutha ziphinde futhi zisetshenziselwe ukwakha ezinye izinhlelo zamakhompyutha.

[36] Ikhophasi yesiZulu ingafakwa lapha kwi-*NLTK* ibe kanye namakhophasi esiNgisi kanye namakhophasi ezinye izilimi. Okanye singasebenza ngqo ngekhophasi yesiZulu ngokuba siyivule ngqo kuma khompyutha kanye nakwisizindalwazi, njengoba sibona esibonelweni seshumi nanye kanye nase sibonelweni seshumi nambili.

Lokhu kusho ukuthi izinhlelo ezilotshiweyo zingahlanganiswa kanye nezinye izinhlelo ezilotshiweyo ukwakha izinhlelo ezinkulu neziphelele. Lezi zinhlelo ezilotshiweyo lapha ngaphezulu yizinhlelo ezilulana, ezingenzima neze, futhi okulula impela nokuziloba. Kodwa-ke, izinhlelo zingaba nkudlwana, zibe nzinyana, ngokuba kwengezwe izinhlosongqangi zemisebenzi yazo. Ucwaningo oluzokwelama lolu luzobheka ukuba singazihlela kanjani lezi zinhlelo ukuba zikwazi ukusetshenziswa nguwonkewonke. Ngale ndlela, lezi zinhlelo ezilotshiweyo ziyobe sezisebenza okwangempela emphakathini, sezisetshenziswa wuluntu lonkana.

Okubalulekile-ke, nokuyinhlosongqangi jikelele yalolu cwaningo, wukuba lufundise ngokuba singalwenza kanjani ucwaningo emibhalweni yesiZulu sisebenzisa ikhophasi yesiZulu kanye nezinsizanhlelo ze*Python.* Uma kuhlaziywa ikhophasi yolimi lwemvelo, kuyaye kubhekwe o*keyword*, ama*concordance* kanye no*collocation*, o*wordlists*, o*word frequency* kanti futhi kwesinye isikhathi kuyaye kubhekwe no*word cloud generation.* Lolu cwaningo luhlose ukubonisa ukuthi ama*regular expressions* e*Python* angasetshenziswa ukwenza ucwaningo lwanoma yiluphi uhlobo ekhophasini yesiZulu. Ngenhla, sibonise ukuthi singazisebenzisa kanjani izinsizahlelo zama*regular expressions* ukuhlaziya imibhalo kanye nekhophasi yesiZulu. I*search* enye yezinsizanhlelo ebalulekile ekuhlaziyeni imibhalo yesiZulu kanye nekhophasi yonkana. Ama*regular expressions* anensizanhlelo i-*re.search.* Lena yinsizanhlelo engacwasi ngokolimi, ekwazi ukuthungatha kanye nokutomula ibinzana lezakhi kanye namagama lawa adingakalayo emibhalweni. Isibonelo sokuqala, nesesibili, nesesithathu, nesesithupha kanye nesesikhombisa, zibonisile ukuba singayisebenzisa kanjani le nsizanhlelo emibhalweni yesiZulu. Ukuphequlula emibhalweni ebhaliweyo ukuzama ukuthola ibinzana lezakhi kanye namagama adingakalayo, kungathatha isikhathi eside impela. I-*re.search* yenza inqubo yokuthungatha izinhlamvana kanye namaganyana adingakalayo ukuba isheshe futhi ibe lula.

Insizanhlelo i*findall* ithi ayenze umsebenzi ocishe ufane nowensizanhlelo i*search.* I*findall* ikwazi ukuwola *yonke into* esekhophasini. Isibonelo sesine kanye nesesihlanu sitshengisa ukuba le nsizanhlelo ingasetshenziswa kanjani emibhalweni yesiZulu. Ukuhlela ikhophasi ngokohlu lwamagama ayo kubaluleke kakhulu njengengqikithi yokuhlela kanye nokuhlaziya ikhophasi. I*findall* ingasetshenziselwa, kokunye, ukuhlela ikhophasi ngokohlu lamagama ayo.

Insizanhlelo i-*re.sub* yona ingasetshenziselwa ukushintsha izinhlamvu

zamagama okanye amagama uqobo lwawo emibhalweni kanye nasekhophasini. Ake senze isibonelo, sithi mhlawumbe ulungisa 'amaphutha' emibhalo ekhophasini; ake sithi mhlawumbe uhlamvana lwegama u-*la* ubhaleke njengo *!a* ngenkathi kugaywa ikhophasi. I-*re.sub* ingashintsha 'iphutha' u-*!a* kuyo yonke ikhophasi, ilenze lelo 'phutha' kube wuhlamvana olwamukelekileyo esiZulwini, u-*la.* Lesi esinye nje isibonelo esitshengisa indlela i-*re.sub* engasetshenziswa ngayo emibhalweni yolimi lwesiZulu. Kuningi futhi okunye okungenziwa yile nsizanhlelo i-*re.sub.*

Ukusetshenziswa kwama*regular expressions* kusiza ukuba kuthungathwe imithetho yokupela kanye nemithetho yohlelo yolimi eyamukelekileyo. Kwizingcwengamsindo, nakwizingcwengazinhlamvu magama, kanye nasemagameni nasemishweni kukhona imithetho yakhona okumele ifundiswe amakhompyutha. Insizanhlelo i*pattern = re.compile* esesibonelweni sesishiyagalolunye kanye nasesibonelweni seshumi, itshengisa kahle kamhlophe ukuthi imithetho ingathungathwa kanjani olimini. Uma imithetho isiqoqiwe, ikhompyutha iyobe isikwazi ukuba iyisebenzise leyo mithetho ukuze iluqonde ulimi lwabantu. Uma sibheka imithetho yokwakheka kolimi lwesiZulu, masingabheki nje kuphela imithetho yokwakheka kwamagama kanye nemisho; kepha kuyomele futhi sikhumbule ukuxilonga nemithetho yokwakheka kwezakhi zamagama. Isibonelo sesishiyagalolunye sibonisa ubunjalo bohlamvana lwegama u-*'lem'*[37]. Ngalolu hlamvana u-*'lem'* kungafakazwa manje kuthiwe lwamukelekile olimini lwesiZulu njengoba insizanhlelo isitshengisile nje.

Isibonelo seshumi nanye kanye nesibonelo seshumi nambili zibonisa ukuthi kungasetshenzwa kanjani nekhophasi enkulu uqobo lwayo. Ikhophasi kungasetshenzwa ngayo ibe ikwikhompyutha noma ibe ikwisizindalwazi. Ukuhlaziywa kwekhophasi okufana ne*keyness,* ne*wordlist* kanye ne*concordance* sekungenziwa manje esiZulwini kusetshenziswa kuphela uhlelo lwe*Python.* Ucwaningo oluzokwelama lolu luhlose ukucubungula ikhophasi yesiZulu ngokwenaba okujulileyo nokugculisayo. Isibonelo seshumi nantathu kanye nesibonelo seshumi nane zibonisile ukuba i-*NLTK* icwasa ngokolimi.

Muningi umsebenzi okusamele wenziwe mayelana nokucubungula isiZulu ngaphansi komkhakha wamakhompyutha. Okokuqala nje, ucwaningo

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[37]U-*'lem'* akasiye isakhi esiyimofimi esiZulwini, kepha uwuluhlamvana lwengxenye yegama elamukelekile esiZulwini, njengoba insizanhlelo i-*matches = pattern.finditer* itshengisile nje.

ekusetshenzisweni kwamakhompyutha esiZulwini kumele luqhubeke. Lapho okufundwa khona ulimi lwesiZulu, kumele kube khona isifundo esifundisa siphinde sicwaninge ngobudlelwano phakathi kwamakhompyutha nesiZulu.

Okwesibili, eminye imisebenzi esasalele esiZulwini, ukuhlelwa kwamagama ngokwemisuka yawo kanye nangokwezingcezu zenkulumo zawo. Kumele kufundiswe amakhompyutha ukuba akwazi ukuhlela amagama esiZulu ngokwemisuka yawo, aphinde futhi akwazi ukuwahlela ngokwezingcezu zenkulumo zawo. Lokhu sekuyenzeka manje esiNgisini kanye nakwezinye izilimi ezithuthukileyo. Okwesithathu, amakhompyutha kumele futhi afundiswe nokuphimisa amagama esiZulu, lokhu esithi phecelezi i*text to speech recognition*[38]. Kumele futhi aphinde afundiswe 'nokuwezwa' amagama esiZulu, lokhu esithi i*speech recognition* noma yi*speech to text*[39]. Lokhu okubaluliwe lapha ngaphezulu izibonelo nje ezimbalwa. Kuningi kakhulu impela okusamele kwenziwe.

Uhlelo lwe*Python* wuhlelo oluhle impela lokubumba izinhlelo ezisetshenziswa kumakhompyutha nakomakhalekhukhwini. Lolu hlelo, njengoba sekuveziwe kulolu cwaningo, lungasetshenziswa futhi ukuhlaziya kanye nokuthuthukisa ulimi lwesiZulu. Lolu hlelo lwe*Python*, uma luqhathaniswa nezinye izinhlelo, lulula kakhulu ukulufunda kanye nokulusebenzisa. Iningi labantu lungalufunda lolu hlelo bese lusetshenziselwa ukuphusisa kanye nokuthuthukisa ulimi lwaboHlanga. Lolu cwaningo, ngaphansi komhlahlandlela wekhophasi, luveze izindlela ezingasetshenziswa ukucubungula isiZulu ngaphansi kwezinhlelo zamakhompyutha. Uma kuqhutshekwa kusetshenziswa izinsizanhlelo zamakhompyutha ekucubunguleni kanye nasekuhlaziyeni isiZulu, uma futhi izinhlelo zamakhompyutha zakhelwa isiZulu, lokho kuyobe kusho ukuphucuzeka kwaso isiZulu.

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[38] Kumele kubalulwe ukuba inkampani iMicrosoft isiwenzile umsebenzi we*text to speech recognition* esiZulwini. Lokhu kufakazelwa ukuba khona kukaThando kanye noThema kwi*Microsoft office* abakwazi ukufunda isiZulu. Kodwa-ke, umsebenzi we*text to speech recognition* esiZulwini kusamele uqhutshwe, ube sesimweni esingcono kunalesi okusona njengamanje.

[39] Inkampani iGoogle isiwenzile umsebenzi we*speech to text recognition* esiZulwini. I*speech to text recognition* yesiZulu itholakala ngaphansi kwethuluzi i*dictation* ku*Google docs.* Yize noma lo msebenzi usuwenziwe, usangaqhutshwa futhi wenziwe ube ngcono.

Isiphetho

Lolu cwaningo luhlose ukufaka intshisekelo ukuba abacwaningi baqale ukuhlongoza ukuhlaziya ulimi lwesiZulu ngaphansi kwezinhlelo zamakhompyutha ezifana no*Python.* Uma kuqhathaniswa isiZulu kanye nesiNgisi, kuvela kube sobala ukuthi kuningi okusamele kwenziwe esiZulwini uma sekuziwa ngakwezamakhompyutha. Kuningi futhi okusamele kwenziwe ngama*regular expressions* esiZulwini. Ucwaningo oluzokwelama lolu, luzothi alufuze lolu ekutheni inhloso yalo – njengoba sibonile futhi lapha – kuzoba wukuzama ukufundisa abantu ukuba izinhlelo zamakhompyutha kumele ziqale manje zamukelwe emfundweni ephakeme, zamukelwe emfundweni yezezilimi, ezikweni lezikole zezesintu kanye nasezikweni lezikole zobuciko. Okubaluleke kakhulu futhi wukuthi izinhlelo ezilotshwe phansi lapha zihlelwe ngendlela yokuthi ziyasabalaliseka ukuze zifinyelele kuwo wonke umuntu, futhi zikwazi ukuba zisetshenziswe ngabantu abazidingayo, abafuna ukuzisebenzisa. Ngaphezu kwalokho, ucwaningo olulandelayo luhlose ukwakha izinhlelo ezikwazi ukuhlela amagama esiZulu ngokwemisuka yawo. Okubalulekile wukuba lolu cwaningo lubonise ingxenye yokusebenza nge*Python* engacwasi ngokolimi. Ngaphezu kwalokho, okuvele kwacaca kulolu cwaningo wukuba siyakwazi ukusebenzisa izinhlelo ze*Python* ezikhethekileyo ukuhlaziya ikhophasi yesiZulu. Lolu cwaningo luhlose ukufaka intshisekelo ukuba kuqhutshekwe kwenziwe olunye ucwaningo olwengeziwe olimini lwesiZulu, kwikhophasi yesiZulu kanye nasekwakheni izinhlelo zamakhompyutha ezisebenza ngolimi lwesiZulu. Lolu cwaningo lubonise ingqikithi yokusetshenziswa kwezinsizanhlelo zamakhompyutha esiZulwini. Ukusetshenziswa kwezinhlelo zamakhompyutha esiZulwini kuveza amanye amaqhinga okuba isiZulu singafundwa siphinde sifundiswe kanjani.

Imithombo Yolwazi

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