

Semantic Matching Application

Natural Language Processing
CS- 6320

by

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Problem Description:

Given 50 frequently asked questions (FAQs) about hummingbirds, the task is to implement a naïve approach and a more sophisticated approach using Natural Language Processing techniques to retrieve the most related FAQs when presented with a user's question about hummingbirds. For instance, when the user asks "How many years will a hummingbird live?", the system must attempt to provide a ranked list of the most relevant FAQs. The naïve approach should treat the questions and answers as bags of words and match the word tokens against a user's question. The other approach must use tokens, lemmas, stems, parts of speech, parse trees, and Wordnet to find matches in a more intelligent way.

Proposed Solution:

We propose the following solution:

1. **Collection of features.** The process is the same for the FAQs and for the questions that the user gives, except that the question and answer must be done together for the FAQ, so will describe that process. The question and answer are combined to form one block of text. The resulting text is then tokenized by NLTK. Stopwords are removed, and this is collected as the feature. Then the words are lemmatized, stemmed, and part-of-speech tagged to produce three more feature sets. The text is then parsed with a dependency parser to retrieve dependency relations. Then, the Lesk algorithm is run on all lemmas to determine the correct Wordnet synset. This is done to collect the best possible synset from the given context. From the dependency graphs, we extract 3-tuples consisting of the two related words and the dependency. We also extract 2-tuples of each word in the dependency graph and its relation. From wordnet, we collect definitions, examples, synset lemmas, antonyms, meronyms, holonyms, hypernyms, and hyponyms. A more detailed description of each feature follows:
 - a. Tokens.
 - b. Tokens without stopwords.
 - c. Lemmas
 - d. Stems
 - e. Part-of-speech tags
 - f. Synset lemmas
 - g. Antonym lemmas
 - h. Hyponym lemmas
 - i. Hypernym lemmas
 - j. Part meronym lemmas
 - k. Part holonym lemmas
 - l. Member meronym lemmas

- m. Member holonym lemmas
- n. Substance meronym lemmas
- o. Substance holonym lemmas
- p. Synset definition tokens
- q. Synset example tokens
- r. 3-tuples of word dependencies
- s. 2-tuples of words and their relations
- t. JCN similarity of the verb synsets
- u. JCN similarity of the noun synsets

2. **Processing of features.** Features a – s are all converted into frequency vectors. If a token occurs 3 times, in an FAQ, then that FAQ will have a 3 in that part of its token vector for feature a (and also feature b if the token is not a stopword). The vectors from the user question are combined with the vectors in each FAQ via cosine similarity. This provides a simple measure of how similar those 19 features are between the user's question and each of the FAQs. From these, 19 scalar values are generated for each FAQ combined with the user's question. Then, the verb synsets in the question are compared via JCN similarity against the verb synsets in each FAQ and converted into a scalar value between 0 and 1. This is done by taking the norm of the vector of all of the similarities and dividing it by the norm of a vector with all 1s to generate a scalar value within the desired range. Then, the same is done with all nouns synsets as was done with the verb synsets. This, finally, produces 21 scalar values for each FAQ paired with the user's question. These are combined into one vector, which we will call the **feature list vector**.
3. **Weights.** There is a weight vector of the same size as the feature list vector which determines the value of each feature to the final score. This is learned via simulated annealing, and this process is explained soon. The features are divided up into so many pieces (21 to be exact) to allow the weights to more accurately adjust their meaningfulness in the output.
4. **Calculating the final score.** The final score is calculated by first multiplying each element of the feature list vector with each corresponding element of the weights vector. Then, the norm of the resulting vector is divided by the norm of the weights vector to give a number between 0 and 1.
5. **Learning weights.** A weight vector of the same size as the feature list vector is created during training, using the following steps:
 - a. A list of training questions and desired answers is provided. All weights are initialized to the same number, usually something between 0 and 1.
 - b. Simulated annealing is used to learn the weights for this training set. Simulated annealing attempts to choose nearby states with a similar score to the current state and transition to that state with a certain

probability. Over time, as the “temperature” decreases, the likelihood of transitioning to a new state becomes less and less. This means that the algorithm will be less likely to move away from local maximums as time goes on. The system prefers to move to states with lower energy (lower energy = a better NLP score), but the system can move in either direction. Over time, the energy is minimized and the NLP score is maximized.

- i. The energy function used is simply 1 minus the average of all of the NLP scores for the questions, so it tends to 0 as the NLP score average tends to 1.
- ii. The temperature function used is simply a downward linear movement starting from the maximum temperature and reaching 0 at the end of the algorithm.
- iii. The probability function used always moves to new states that have a lower energy. Otherwise, the closer the state is, the more likely the movement is to be taken. Also, the higher the temperature (and subsequently the earlier on in the algorithm), the more likely the movement is to be taken.
- iv. The neighbor function chooses a random weight (out of the 21 total weights), a random adjustment (currently set to between 0.001 and 0.01), and a random sign (increase or decrease the weight) and adjusts the weight and returns the new proposed weight vector.

6. **Usage.** Once the weight vector has been learned, FAQs can be returned for a given user question by comparing the question to all FAQs using the scoring algorithm described above and the learned weights vector and then ranking them by descending score.

Programming Tools:

Python 3

Python 3 is the primary programming language used for this project.

Java

While no Java code was written by the team members, jar libraries from the Stanford Parser were used for dependency parsing.

NLTK

Natural Language Toolkit. This is a library for Python that provides a host of natural language processing tools. These include access to wordnet, various corpora, and dependency parsers.

Stanford Parser

Stanford’s dependency parser was used to get dependency trees from questions and answers. We used a python library that wrapped the java libraries.

Wordnet

The wordnet corpus was used via NLTK. We collected synsets via the Lesk algorithm and used their similarities and definitions and examples. We also used the Brown corpus for information content that was exposed via Wordnet.

Brown Corpus

We used the Brown corpus that was provided with Wordnet for the information content when we took the JCN similarity of various synsets.

Numpy

Numpy is a Python library that we used for linear algebra operations such as taking the norm of a vector.

Sklearn

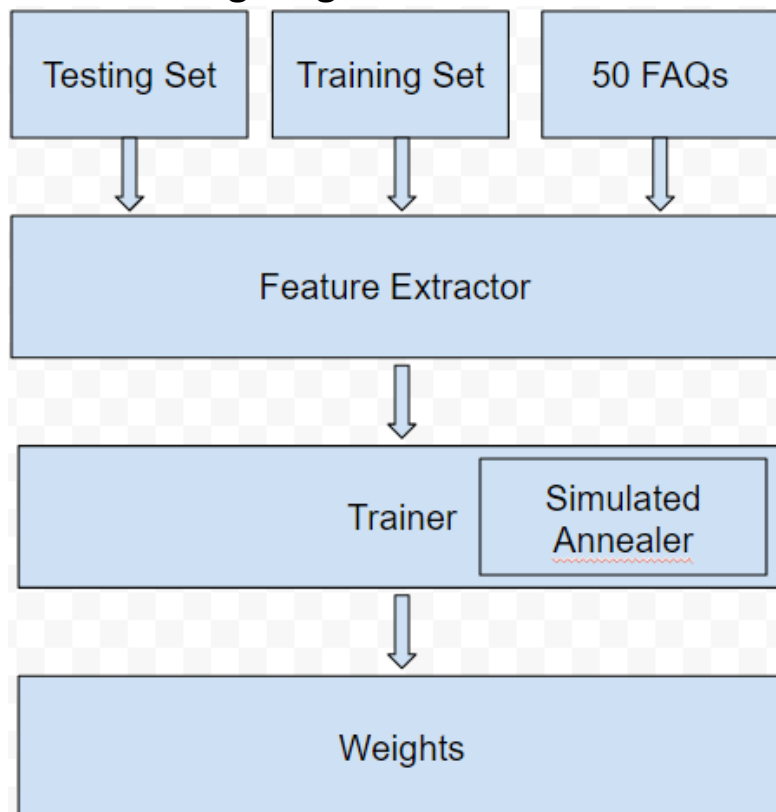
Sklearn is a Python library that we used for cosine similarity calculations.

Brown Corpus

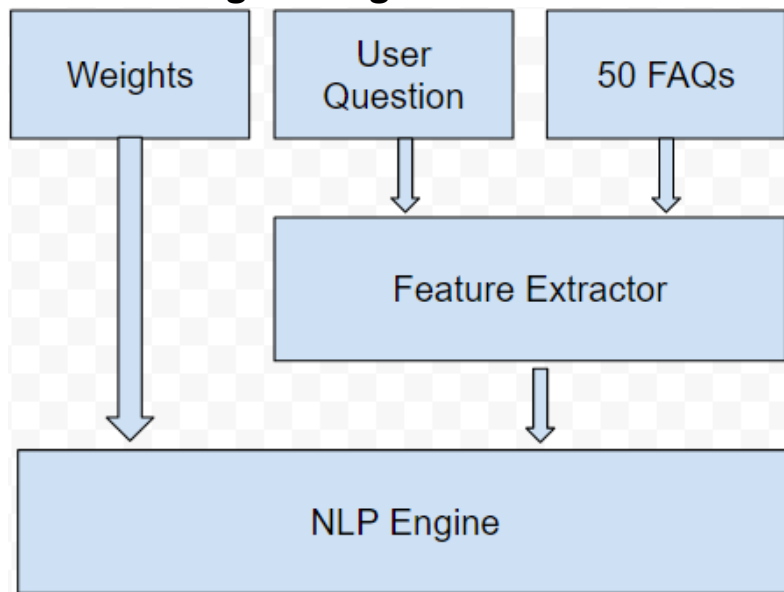
We used the Brown corpus that was provided with Wordnet for the information content when we took the JCN similarity of various synsets.

Architectural Diagram:

1. Training Diagram



2. NLP Engine Diagram



Implementation Details:

TASK-1

Task 1 includes creating an input corpus of 50 FAQs. The corpus is based on a hummingbird's life. We have 50 questions and its corresponding answers for our corpus.

TASK-2

BAG OF WORDS:

Description: A bag-of-words model in natural language processing which is used for extracting features from the corpus. The approach is very simple and flexible for extracting features from documents. It will categorize the corpus by matching the different features and identify which bag contains the same set of features / block of same text. This model searches for the occurrence of words in the document.

It is called a “*bag*” of words because the order of the text is not considered here. The model is only checked if the given words are present in any bag of words. The stop words are not considered while looking for matching text.

Implementation: The FAQ is considered a corpus and a bag of words is created using each question and corresponding answer. For our corpus, which has 50 FAQs, we have created 50 bags of words. The user of this algorithm has to provide an input question and from the input question a Bag of Words will be created removing stop words and will be provided as input to the BOW algorithm.

For the input question features, a vector is formed which has the frequency of each word. Each word in the input question will be compared to each question and answer (50 FAQs) in the FAQ and if any of the words from the input question are present in the FAQ it will create a similar vector with counts for the corresponding FAQ question and answer.

Once all the count vectors are created for all FAQ bags of words it will compare the similarity between each FAQ vector and the given question's vector. Here the cosine similarity is used to find the similarity between 2 count vectors. A higher similarity value indicates a better matching answer. The output for this algorithm shows the top 10 matching answers for the user's given question.

Running result:

***** Hummingbird FAQ engine powered by NLTK *****

Input your question: How fast do hummingbirds' wings beat per second?

Given user question: How fast do hummingbirds' wings beat per second?

Top 10 results from Bag of words algorithm are:

Hummingbirds' wings can beat at about 70 times per second in normal flight and about 200 times per second during a high speed dive. [0.914659120760047](#)

It depends on the size of the bird. The largest, the Giant Hummingbird, has a wingbeat rate of 10-15 per second. The fastest recorded rate was about 80 per second, on a tiny Amethyst Woodstar, and the slightly smaller Bee Hummingbird - the world's smallest bird - may have an even faster rate. Common small North American hummingbirds like the Ruby-throated and Rufous average around 53 per second in normal flight. [0.8520128672302583](#)

A rate of 1260 beats per minute was measured in a Blue-throated Hummingbird. In torpid hummingbirds, the heart rate can drop to 50-180 per minute. [0.7777777777777777](#)

A hummingbird can lick 10-15 times per second while feeding. [0.7453559924999298](#)

Hummingbirds can fly in the rain and, like dogs, shake their heads to dispel drops of water. Unlike dogs, however, a hummingbird shakes its head violently, 132 times per second, and rotating 202 degrees - all while flying and maintaining direction! [0.6666666666666666](#)

A hummingbird flies at an average speed of 25-30 miles per hour and can do a fast dive at up to 60 miles per hour. [0.6324555320336759](#)

There are more than 325 unique hummingbird species in the world. Only eight species regularly breed in the United States, though up to two dozen species may visit the country or be reported as regular vagrants. The rest of the hummingbirds are primarily tropical species and do not regularly migrate. They are found in Central and South America as well as throughout the Caribbean.

[0.5773502691896257](#)

Hummingbirds have 1,000-1,500 feathers, the fewest number of feathers of any bird species in the world. Not only do they not need as many feathers because of their tiny size, but fewer feathers also keeps them more lightweight for easier flight. [0.5773502691896257](#)

At rest, a hummingbird takes an average of 250 breaths per minute. Their breathing pace will increase when they are in flight. [0.5443310539518174](#)

Female hummingbirds lay only two eggs. [0.5443310539518174](#)

TASK-3

Please see the “Proposed Solution” section above for the description of the features obtained and how they are used. A simplistic view is that the following features are used: tokens, tokens without stop words, lemmas, stems, part-of-speech tags, synset lemmas, antonym lemmas, hyponym lemmas, hypernym lemmas, hypernym lemmas, part_meronym_lemmas, part_holonym_lemmas, member_meronym_lemmas, member_holonym_lemmas, substance_meronym_lemmas, substance_holonym_lemmas, wordnet definitions, wordnet examples, dependency graph dependencies, dependency graph relations, verb synset JCN similarities, and noun synset JCN similarities.

TASK-4

Please see the “Proposed Solution” section above for a detailed description of how Task 4 was implemented, including training and usage. A high-level summary is that 21 features were collected, and a weight was applied to each one. The weights were learned via simulated annealing.

Evaluation Metric:

Description: The **mean reciprocal rank(MRR)** is a statistical measure for evaluating any process that produces a list of possible responses to a sample of queries, ordered by probability of correctness. The reciprocal rank of a query response is the multiplicative inverse of the rank of the first correct answer: $1/1 = 1$ for first place, $1/2$ for second place, $1/3$ for third place and so on. The mean reciprocal rank is the average of the reciprocal ranks of results for a sample of queries.

$$\text{MRR} = \frac{1}{|Q|} \sum_{i=1}^{|Q|} \frac{1}{\text{rank}_i}.$$

$\text{rank}(i)$ refers to the rank position of the first relevant document for the i -th query.

Implementation: The MRR is used for evaluating the performance of both Bag of Words and algorithm using deeper NLP pipeline. The MRR for both the algorithms is applied considering 10 FAQ questions (which includes some original exact questions from FAQ corpus, original questions having jumbled words, some new questions, questions having synonyms head words) and its corresponding expected answer.

The application of the BoW algorithm and deeper NLP algorithm, on each question (10 FAQ) will derive the reciprocal rank based on the position of expected correct answers within top 10 output. If the expected answer is not present in the top 10 output, we are considering its RR as 0. After getting all the RR for 10 questions, the MRR is calculated.

Evaluation of Bag of Words:

```
Question is: What is the rate of flight of a hummingbird in the air?
Correct answer at index: -1
-----
Question is: Can hummingbirds harm a flower?
Correct answer at index: -1
-----
Question is: Are nests used again?
Correct answer at index: -1
-----
Question is: Might a hummingbird use a termite or an insect as a food source?
Correct answer at index: -1
-----
Question is: During which seasons do hummingbirds settle down in their nests?
Correct answer at index: -1
-----
Question is: Do scents help hummingbirds find a flower?
Correct answer at index: 0
-----
Question is: When migrating, will hummingbirds perch on different types of birds for a continuous trip with no effort?
Correct answer at index: 2
-----
Question is: What scent can hummingbirds detect?
Correct answer at index: -1
-----
Question is: How is food consumed and what body parts are used?
Correct answer at index: -1
-----
Question is: What continents are hummingbirds located in?
Correct answer at index: -1
-----
*****
MRR EVALUATION for algorithm: BagOfWords
*****
What is the rate of flight of a hummingbird in the air? 0
Can hummingbirds harm a flower? 0
Are nests used again? 0
Might a hummingbird use a termite or an insect as a food source? 0
During which seasons do hummingbirds settle down in their nests? 0
Do scents help hummingbirds find a flower? 1.0
When migrating, will hummingbirds perch on different types of birds for a continuous trip with no effort? 0.3333333333333333
What scent can hummingbirds detect? 0
How is food consumed and what body parts are used? 0
What continents are hummingbirds located in? 0
None
-----
Total MRR of the QA Set: 0.1333333333333333
```

Evaluation of NLP search engine:

```
Question is: What is the rate of flight of a hummingbird in the air?
Correct answer at index: -1
-----
Question is: Can hummingbirds harm a flower?
Correct answer at index: 0
-----
Question is: Are nests used again?
Correct answer at index: 2
-----
Question is: Might a hummingbird use a termite or an insect as a food source?
Correct answer at index: -1
-----
Question is: During which seasons do hummingbirds settle down in their nests?
Correct answer at index: 5
-----
Question is: Do scents help hummingbirds find a flower?
Correct answer at index: 4
-----
Question is: When migrating, will hummingbirds perch on different types of birds for a continuous trip with no effort?
Correct answer at index: 1
-----
Question is: What scent can hummingbirds detect?
Correct answer at index: 5
-----
Question is: How is food consumed and what body parts are used?
Correct answer at index: -1
-----
Question is: What continents are hummingbirds located in?
Correct answer at index: 0
-----
*****
MRR EVALUATION for algorithm: NLP Pipeline
*****
What is the rate of flight of a hummingbird in the air? 0
Can hummingbirds harm a flower? 1.0
Are nests used again? 0.3333333333333333
Might a hummingbird use a termite or an insect as a food source? 0
During which seasons do hummingbirds settle down in their nests? 0.16666666666666666
Do scents help hummingbirds find a flower? 0.2
When migrating, will hummingbirds perch on different types of birds for a continuous trip with no effort? 0.5
What scent can hummingbirds detect? 0.16666666666666666
How is food consumed and what body parts are used? 0
What continents are hummingbirds located in? 1.0
None
-----
Total MRR of the QA Set: 0.33666666666666667
```

Problems Encountered:

The first problem encountered was that the synsets were not very accurate. This was due to the parts of speech being inaccurate and also due to just taking the first synset for everything. Using Lesk and fixing the parts of speech improved the synsets. Another problem encountered was the parts of speech. These were wrong and inaccurate because the stop words had been removed before tagging. Thirdly, the Stanford Dependency Parser ran out of memory. We had to shorten the sentences involved to allow it to finish in time. Finally, I made a programming mistake and kept having situations where the dependency parse trees had treated each character as a token instead of each word. The results weren't good, as can be expected.

Pending Issues:

The main pending issue is efficiency. There were a number of tradeoffs in favor of short code taken in both training and usage that cause the implementation to not be as fast as it could be. In practice, it's not a big issue, but the solution as is would not scale. The cosine similarity calculations can be sped up by not creating so many intermediate data structures, and numpy's norm calculation is not as fast as other methods. Training takes a very long time with enough iterations (30000 or so) and more than 30 or so questions.

Potential Improvements:

1. Lesk can be improved by removing stopwords in the comparison. They needlessly increase the value of certain synsets. Some words, such as "United States", are being tagged with synsets separately, even though the synset "united_states.n.01" exists. Also, part of speech tags were not taken into account when performing lesk, so some words received synsets with the wrong part of speech.
2. The corpus could have longer questions and longer answers. This would allow more surface area for feature removal. Some of the answers are rather short right now.
3. The weights could benefit from being less linear.
4. The information content of words could be used to reduce the effect on scoring of words that occur often in the corpus. This improvement could be applied to most of the features and would probably give a marked improvement.
5. There are many parameters in the simulated annealing algorithm, and they can be adjusted to train the weights better. The temperature could be cooled at a non-linear pace. Also, the energy function could have a number of improvements. Currently, it takes an average of the scores, but this does not take into account how the correct answers are performing compared to others (for instance, if the right answer has a very high score but is still coming in last,

then that is not a good state to be in). Adjusting the energy function could do a lot of good for finding global maximums and avoiding local maximums.

6. As stated in the “pending issues” section, there are lots of efficiency issues that can be addressed that would allow a much more extensive training set to be used to train the model.
7. More wordnet features could likely help. Adverb and adjective similarities could be added, and other corpora could be checked to see if they have better information content than the Brown corpus for the current domain. Also, currently we don’t take definitions and examples from related synsets, and these could help as well.

Reference:

1. <http://www.worldofhummingbirds.com/faqs.php>
2. <https://www.birdwatchersdigest.com/bwdsite/learn/hummingbirds/faqs.php>
3. <https://www.wildbirdscoop.com/hummingbird-faq.html>
4. <https://en.wikipedia.org/wiki/Hummingbird>
5. <https://www.thespruce.com/fun-facts-about-hummingbirds-387106>
6. <https://defenders.org/hummingbirds/basic-facts>
7. http://hummingbirds.ucdavis.edu/hummingbird_information/interesting_facts.cfm
8. <http://www.worldofhummingbirds.com/facts.php>
9. <http://www.hummingbirds.net/about.html>
10. <http://hummingbirdwebsite.com/hummingbird-facts.cfm>
11. https://www.nps.gov/cham/learn/nature/upload/Hummingbirds-of-Chamizal_english.pdf
12. <https://www.hummingworlds.com/>
13. <http://www.nltk.org/howto/wordnet.html>

1. When is hummingbird season?

This depends on where you are located. In North America, hummingbirds can start to arrive starting as early as February and end as late as October. In the southern portions of the United States, Mexico, Central America, and South America, hummingbirds live all year long. The best way to find out what your hummingbird season is, is to start writing down the first and last times you see a hummingbird every year in a journal. You will be able to see a pattern after a couple of years.

2. Where do hummingbirds go in the winter?

Hummingbirds that migrate will go anywhere from the southern United States to Mexico, Panama, and the Yucatan Peninsula for the winter.

3. Where do hummingbirds live?

Hummingbirds live in the Americas as far north as Alaska and as far south as Chile.

4. What is the reproduction process like for hummingbirds?

Two white eggs are laid, which despite being the smallest of all bird eggs, are in fact large relative to the adult hummingbird's size. Incubation lasts 14 to 23 days, depending on the species, ambient temperature, and female attentiveness to the nest. The mother feeds her nestlings on small arthropods and nectar by inserting her bill into the open mouth of a nestling, and then regurgitating the food into its crop.

5. How fast does a hummingbird fly?

A hummingbird flies at an average speed of 25-30 miles per hour and can do a fast dive at up to 60 miles per hour.

6. Do hummingbirds damage flowers?

No. Flowers love hummingbirds. Flowers need hummingbirds to help with pollination. Plants will position their flowers outward so the hummingbirds can easily reach them.

7. Do hummingbirds reuse their nest?

Hummingbirds can reuse their nest if the nest survives the winter months. Do not try to save a nest for a hummingbird since illegal in the United States and many other countries.

8. How much nectar does a hummingbird consume in a day?

A hummingbird can consume anywhere between half (0.5) to eight (8) times their body weight in one day.

9. Do hummingbirds eat termites?

Not really. Termites have a tough exoskeleton that hummingbirds don't like to have to deal with unless they have to. Hummingbirds prefer softer insects.

10. What is a hummingbird's lifecycle?

A hummingbird is born from an egg that is the size of a very small pea. They will spend about three weeks in the nest. When they are old enough, they will fly away and not return to the nest. If they can survive the first year of life, they will live for approximately 5 years."

11. What do hummingbirds eat?

Hummingbirds drink nectar from hummingbird feeders and flowers. They eat small soft insects and bugs.

12. When do hummingbirds nest?

In North America, hummingbirds will nest in the spring and early summer. In South and Central America, hummingbird will nest in both the summer and the winter (North American time)."

13. Does a hummingbird find flowers by smell?

Hummingbirds have little or no sense of smell. Most good hummingbird plants have no fragrance, and the hummingbird plants that do have a fragrance [Japanese honeysuckle, for instance] are exotics, usually Asian or African in origin. Therefore, it would be incorrect to say that hummingbirds are drawn to any flowers because of the scent.

14. How fast do hummingbird wings beat? How do they move?

It depends on the size of the bird. The largest, the Giant Hummingbird, has a wingbeat rate of 10-15 per second. The fastest recorded rate was about 80 per second, on a tiny Amethyst Woodstar, and the slightly smaller Bee Hummingbird - the world's smallest bird - may have an even faster rate. Common small North American hummingbirds like the Ruby-throated and Rufous average around 53 per second in normal flight.

15. How fast do hummingbird hearts beat?

A rate of 1260 beats per minute was measured in a Blue-throated Hummingbird. In torpid hummingbirds, the heart rate can drop to 50-180 per minute."

16. How long does a hummingbird live?

Not much is known about their lifespan, but many experts believe the average is about 3 to 5 years. The current record holder is a female Broad-tailed Hummingbird. She was banded as an adult in Colorado in 1976 and recaptured in the same location in 1987, which would have made her at least 12 years old."

17. How many species are there?

There are more than 325 unique hummingbird species in the world. Only eight species regularly breed in the United States, though up to two dozen species may visit the country or be reported as regular vagrants. The rest of the hummingbirds are primarily tropical species and do not regularly migrate. They are found in Central and South America as well as throughout the Caribbean."

18. What makes a hummingbird's throat bright and colorful?

A hummingbird's brilliant throat color is not caused by feather pigmentation, but rather by iridescence in the arrangement of the feathers. Light level, moisture, angle of viewing, wear and tear and other factors all influence just how bright and colorful the throat may appear."

19. Can hummingbirds walk?

Hummingbirds cannot walk or hop, though their feet can be used to scoot sideways while they are perched. These birds have evolved smaller feet to be lighter for more efficient flying. They will use their feet for itching and preening, however!"

20. What is the smallest hummingbird?

The calliope hummingbird is the smallest bird species in North America and measures just 3 inches long. The bee hummingbird is the smallest hummingbird species in the world and measures 2.25 inches long. It is only found in Cuba.

21. How many feathers do hummingbirds have?

Hummingbirds have 1,000-1,500 feathers, the fewest number of feathers of any bird species in the world. Not only do they not need as many feathers because of their tiny size, but fewer feathers also keeps them more lightweight for easier flight."

22. What part of a hummingbird weighs the most?

Roughly 25-30 percent of a hummingbird's weight is in its pectoral muscles. These are the broad chest muscles principally responsible for flight.

23. How big are a hummingbird's eggs?

Hummingbirds lay the smallest eggs of all birds. Their eggs measure less than one-half inch long but may represent as much as 10 percent of the mother's weight at the time the eggs are laid. A hummingbird egg is smaller than a jelly bean!

24. How many breaths does a hummingbird take per minute?

At rest, a hummingbird takes an average of 250 breaths per minute. Their breathing pace will increase when they are in flight."

25. How far can a hummingbird fly during migration?

The rufous hummingbird has the longest migration of any hummingbird species. These hummers fly more than 3,000 miles from their nesting grounds in Alaska and Canada to their winter habitat in Mexico.

26. Do hummingbirds sit on the backs of other birds during migration?

The ruby-throated hummingbird flies 500 miles nonstop across the Gulf of Mexico during both its spring and fall migrations. It is a myth, however, that these tiny birds ""ride"" on the back of other birds during migration - they fly this distance completely on their own.

27. Can hummingbirds smell?

Hummingbirds have no sense of smell but have very keen eyesight.

28. How do humminbirds eat nectar?

Hummingbirds do not suck nectar through their long bills, they lick it with fringed, forked tongues. Capillary action along the fringe of their tongue helps draw nectar up into their throats so they can swallow.

29. How fast can a hummingbird lick?

A hummingbird can lick 10-15 times per second while feeding.

30. How quickly do humminbirds digest nectar?

Hummingbirds digest natural sucrose - the sugar found in floral nectar - in 20 minutes with 97 percent efficiency for converting the sugar into energy.

31. Is there cross-breeding between species?

Many hummingbird species, including Anna's, black-chinned, Allen's, Costa's, rufous, calliope and broad-tailed hummingbirds, can breed together to create hybrid species. This is one factor that makes identifying hummingbirds very challenging."

32. Are hummingbirds aggressive?

Despite their small size, hummingbirds are one of the most aggressive bird species. They will regularly attack jays, crows and hawks that infringe on their territory. Backyard birders often have one dominant hummingbird that guards all the feeders, chasing intruders away."

33. What is the longest bill a hummingbird can have?

The bill of the aptly named sword-billed hummingbird, found in the Andes Mountains, can reach up to 4 inches long, and it can be so heavy that the birds may perch holding their bills straight up. These birds hold the record for the longest bill relative to overall body size of any bird in the world."

34. Are hummingbirds found in the Eastern Hemisphere?

Hummingbirds are native species of the New World and are not found outside of the Western Hemisphere except in a few zoos or aviaries. There are no hummingbirds found in Europe, Africa, Asia, Australia or Antarctica."

35. What threats are posed to hummingbirds today?

Habitat loss and destruction are the hummingbird's main threats. As hummingbirds are often specially adapted to each unique habitat, each species of hummingbird currently listed as vulnerable or endangered on the IUCN red list are all threatened due to habitat destruction and loss. The earth's changing temperatures due to climate change are affecting hummingbird migratory patterns. Different species are being spotted well outside their normal range. Due to this, it may be harder for them to find food."

36. Can any other birds fly backwards?

Hummingbirds are the only birds that can fly backwards.

37. Do hummingbirds fly often?

A hummingbird's wing beats take up so much energy, they spend the majority of their time resting on branches and twigs."

38. Can hummingbirds fly in the rain?

Hummingbirds can fly in the rain and, like dogs, shake their heads to dispel drops of water. Unlike dogs, however, a hummingbird shakes its head violently, 132 times per second, and rotating 202 degrees - all while flying and maintaining direction!"

39. How does a hummingbird's tongue work?

A hummingbird tongue is flat and split at the tip, bifurcated like a forked tongue. Each of the bifurcated flaps is edged with fringe, which makes the tip of tongue look like a feather. At rest, the flaps are rolled up in tubular shape and stuck together. When a hummingbird feeds, it picks fluid up by protracting the tongue, spreading the bifurcated tip, which opens out flat, gets covered with fluid, then brought back into the mouth."

40. How big is a hummingbird's heart?

A hummingbird's heart is relatively the largest of all animals at 2.5% of its body weight.

41. How many neck vertebrae do hummingbirds have?

Hummingbirds have more neck vertebra (14 or 15) as opposed to most mammals (7).

42. Do hummingbirds store up food for travel?

In preparation for migration, a hummingbird will store half its body weight worth of fat."

43. Do hummingbirds migrate together?

Hummingbirds migrate alone and not in flocks. Very commonly the males migrate first followed by the females.

44. Are hummingbirds an endangered species?

Nearly 15% of hummingbird species are vulnerable to extinction.

45. What predators eat hummingbirds?

It has been reported that very small hummingbirds have been caught in spider webs, stuck on thistles, and eaten by praying mantis, frogs, and dragonflies. Also, predators such as cats can catch and kill hummingbirds."

46. How many eggs do hummingbirds lay?

Female hummingbirds lay only two eggs.

47. Who takes care of newborn hummingbirds?

The male hummingbird is not involved in raising young, and will often find another mate after the young are hatched."

48. How long do baby hummingbirds take to leave the nest?

After hatching, baby hummingbirds will stay in the nest for approximately three weeks."

49. Where do most hummingbird species live?

95% of hummingbird species live primarily south of the United States.

50. Do all hummingbirds build nests?

Only female hummingbirds build nests.