The nanobird Relevancy Engine A Context Analyzer and Suggestion System

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1 The nanobird Relevancy Engine

The *nanobird Relevancy Engine* (nRE) is a system that analyzes an inputted natural language data (text) and extracts a set of phrases that describes and/or summarizes the text. The nRE generates a graph showing the relations between phrases and deduces the context in text. The *nanobird Relevancy Engine* (nRE) is composed of three parts: a set of phrase dictionaries, a phrase tokenizer, and a phrase relevancy/context analyzer (Figure 1).

1.1 Definitions

Word. A single distinct meaningful element of speech or writing, used with others (or sometimes alone) to form a sentence and typically shown with a space on either side when written or printed.

Phrase. A single word or a group of words.

Alias phrases. Phrases that take many different forms and still refer to the same thing/concept.

Ambiguous phrase. A phrase that could refer to many different thing/concept.

1.2 nanobird Phrase Dictionaries

To create a context-aware natural language analyzer, different sets of phrase dictionaries are built, each acting as a cornerstone to the *nanobird* Relevancy Engine. We define/build five different

dictionaries: a dictionary of unambiguous phrases (D_U), a dictionary of ambiguous phrases (D_A), a

dictionary of phrase aliases (D_L), a dictionary of stop phrases (D_S) and a dictionary of phrase fingerprints (D_F).

Each dictionary is an abstract data type composed of a collection of (key,value) pairs such that each possible key appears at most once in the collection. Two different lookups can be performed:

- a lookup to check if a given key exists in the dictionary
- a lookup to find the value (if any) that is bound to a given key

It is important to note that the sets of keys $K_{D_U}, K_{D_A}, K_{D_L}$ of the dictionaries D_U , D_A , and D_L respectively are unique across these dictionaries, that is:

$$K_{\mathbf{D}_U} \prod K_{\mathbf{D}_A} \prod K_{\mathbf{D}_L} = \emptyset$$

1.2.1 Dictionary of unambiguous phrases (D_U)

Generally, a relevancy system requires a dictionary of predefined phrases obtained from different

sources such as encyclopedias and glossaries. The unambiguous phrases dictionary (D_U) consists of predefined phrases extracted from Wikipedia, a free, web-based, collaborative, multilingual encyclopedia.

Each phrase refers to a thing/person/concept that is not open to more than one interpretation. An example of such phrases is "*Billy Apple*", "*Global warming*", and "*Apple Inc*." which refer to something/someone specific. Figure 2 shows a subset of phrases found in the unambiguous phrases dictionary.

Each key (k_{D_U}) in the dictionary D_U consists of a phrase such as "Global warming" and "Apple Inc.". The value associated with each key is not essential to the current implementation.

1.2.2 Dictionary of ambiguous phrases (D_A)

In natural languages, some phrases are open to more than one interpretation and thus may refer to different things/concepts. Learning the different meanings of a phrase is essential to the understanding of a natural language. For instance, the word *"Apple"* can mean any of these following concepts:

- Apple Inc.
- *Apple (fruit)*
- Fiona Apple
- Apple Store

The dictionary of ambiguous phrases provides a list of ambiguous phrases along with the different possible interpretations. Each key k_{D_A} in the dictionary D_A consists of a phrase such as "Apple". The value associated with each key is a list of unambiguous phrases in D_U (Figure 3).

$$\{k, v\}_{D_A} = \{Apple, [Apple Inc., Apple (fruit), Fiona Apple, Apple Store, ...]\}$$

1.2.3 Dictionary of phrase aliases (D_L)

Some phrases may be presented in different forms and still refer to the same thing/concept. These forms range from a simple few character change to a whole phrase change. A dictionary of phrase aliases $\binom{D_L}{D_L}$ is a mapping of each phrase $\binom{k_{D_L}}{D_L}$ to an unambiguous phrase in $\frac{D_U}{D_L}$. For instance, "Global wobble" is an alias to the phrase "Global warming". Figure 4 gives different examples of phrase aliases and their mapping to their equivalent unambiguous phrases.

$$\{k_{i}, v\}_{D_{L}} = \{Climate \ crisis, Global \ warming\}$$
$$\{k_{j}, v\}_{D_{L}} = \{Planetary \ warming, Global \ warming\}$$
$$\{k_{k}, v\}_{D_{L}} = \{Stats, Statistics\}$$

1.2.4 Dictionary of stop phrases (D_s)

The dictionary of stop phrases (D_s) consists of phrases that are filtered out prior to or during the processing of natural language data (text). It is controlled by human input and not automated. Any group of words can be selected as the stop phrases to avoid incorrect context analysis. Examples of stop phrases are "the", "is", "Wednesday", "which", and "lots of".

Each key $\binom{k_{D_s}}{1}$ in the dictionary D_s consists of phrases such as "*the*", "*is*", "*Wednesday*", "*which*", and "*lots of*". The value associated with each key is not essential to the current implementation.

1.2.5 Dictionary of phrase fingerprints (D_F)

A phrase fingerprint is a map representing a phrase and its distance to other relevant phrases.

Figure 5 is an example showing the fingerprint of the phrase "Apple Inc.".

Each key k_{D_F} in the dictionary of phrase fingerprints (D_F) consists of a pair of phrases found in unambiguous phrase dictionary (D_U) . The value associated with each key represents the distance between the pair of phrases.

$$\{k_{i}, v\}_{D_{F}} = \{(Apple Inc., iPad), 0\}$$

$$\{k_{j}, v\}_{D_{F}} = \{(Apple Inc., Mac OS X), 1\}$$

$$\{k_{k}, v\}_{D_{F}} = \{(Apple Inc., Personal computer), 3\}$$

$$\{k_{l}, v\}_{D_{F}} = \{(Apple Inc., Mac OS X Lion), -6\}$$

To build a dictionary of phrase fingerprints (D_F), encyclopedia articles, namely Wikipedia articles, are processed using a proprietary algorithm that correlates phrases within an article and across articles.

1.2.5.1 Phrase Correlation Algorithm

The nanobird Phrase Correlation Algorithm is based on building relations between phrases in Wikipedia articles.

A Wikipedia article can be split into five sections (Figure 6):

- a definition (first paragraph),
- an information box,
- a description (remaining paragraphs up to the first outline),

- a summary of information (the remaining paragraphs of the article), and
- categories section.

Each section contains a set of phrases some of which are relevant to the phrase the article is about. The sets of phrases are built by collecting the phrases in the hyperlink from each section. Once the phrases are collected, they are passed to the nanobird Phrase Correlation algorithm. The algorithm is based on a set of definitions described in the remaining of this section.

1.2.5.1.1 Notations

The following notations are used in describing the Phrase Correlation algorithm

- ω : the phrase (thing/person/concept) the article is about.
- A_{ω} : the article that defines/describes a thing, person or concept.
- $\eta_{(\omega)}^{A}, \eta_{(\omega)}^{B}, \eta_{(\omega)}^{C}, \eta_{(\omega)}^{D}, \eta_{(\omega)}^{E}$: the set of phrases and their aliases in the five sections of A_{ω} (Figure 6).
- $\eta_{(\omega)}$: the complete set of phrases for all sections of A_{ω} such that

$$\eta_{(\omega)} = \eta^{A}_{(\omega)} \cup \eta^{B}_{(\omega)} \cup \eta^{C}_{(\omega)} \cup \eta^{D}_{(\omega)} \cup \eta^{E}_{(\omega)}$$

- $\lambda_{i(\omega)}^{A}$: the *i*th hyperlinked phrase in the "definition" $\eta_{(\omega)}^{A}$
- D: the dictionary of predefined phrases which consists of the combination of the three dictionaries D_U, D_A, D_L

$$D = D_U \cup D_A \cup D_L$$

• $\Lambda^{A}_{(\omega)}, \Lambda^{B}_{(\omega)}, \Lambda^{C}_{(\omega)}, \Lambda^{D}_{(\omega)}$: the set of hyperlink phrases in $\eta^{A}_{(\omega)}, \eta^{B}_{(\omega)}, \eta^{C}_{(\omega)}$, and $\eta^{D}_{(\omega)}$ respectively such that:

$$\Lambda^{A}_{(\omega)} = \left\{ \lambda^{A}_{1(\omega)}, \lambda^{A}_{2(\omega)}, \Box, \lambda^{A}_{(n-1)(\omega)}, \lambda^{A}_{n(\omega)} \right\} \text{ and } \Lambda^{A}_{(\omega)} \subseteq \eta^{A}_{(\omega)}$$
$$\Lambda^{B}_{(\omega)} = \left\{ \lambda^{B}_{1(\omega)}, \lambda^{B}_{2(\omega)}, \Box, \lambda^{B}_{(n-1)(\omega)}, \lambda^{B}_{n(\omega)} \right\} \text{ and } \Lambda^{B}_{(\omega)} \subseteq \eta^{B}_{(\omega)}$$
$$\Lambda^{C}_{(\omega)} = \left\{ \lambda^{C}_{1(\omega)}, \lambda^{C}_{2(\omega)}, \Box, \lambda^{C}_{(n-1)(\omega)}, \lambda^{C}_{n(\omega)} \right\} \text{ and } \Lambda^{C}_{(\omega)} \subseteq \eta^{C}_{(\omega)}$$
$$\Lambda^{D}_{(\omega)} = \left\{ \lambda^{D}_{1(\omega)}, \lambda^{D}_{2(\omega)}, \Box, \lambda^{D}_{(n-1)(\omega)}, \lambda^{D}_{n(\omega)} \right\} \text{ and } \Lambda^{D}_{(\omega)} \subseteq \eta^{D}_{(\omega)}$$

It is important to note that all hyperlinked phrases are part of the dictionary of predefined phrases.

$$\omega \in D$$
 , $\Lambda^{A}_{(\omega)} \subseteq D$, $\Lambda^{B}_{(\omega)} \subseteq D$, $\Lambda^{C}_{(\omega)} \subseteq D$, $\Lambda^{D}_{(\omega)} \subseteq D$

• $\delta_{\omega_i \to \omega_j}$: a signed distance between two phrases ω_i and ω_j ; thus $\delta_{\omega_i \to \omega_j} = -\delta_{\omega_j \to \omega_i}$.

We define 15 different distances between two phrases.

$$0 \le \left| \delta_{\omega_i \to \omega_j} \right| \le 14$$

The closer the absolute distance between two phrases, the more related those two phrases are.

1.2.5.1.2 Definitions

<u>Definition 1</u>: The distance between two phrases ω_i and ω_j is defined to be zero ($\delta_{\omega_i \to \omega_j} \coloneqq 0$) if the following conditions are met:

- ω_i appears in the set of phrases of the "definition" $(\eta^A_{(\omega_j)})$ of the article A_{ω_j} , and
- ω_j is in the set of hyperlinked phrases of the "definition" $(\Lambda^A_{(\omega_i)})$ of the article A_{ω_i}

$$\delta_{\omega_i \to \omega_j} \coloneqq 0 \Leftrightarrow \omega_j \in \Lambda^{\scriptscriptstyle A}_{(\omega_i)} \ \text{where} \ \omega_i \in \eta^{\scriptscriptstyle A}_{(\omega_j)}$$

<u>Definition 2</u>: The distance from phrase ω_i to ω_j is defined to be one $(\delta_{\omega_i \to \omega_j} = 1)$ if the following conditions are met:

- ω_i appears in the set of phrases of the "information box" $(\eta^{B}_{(\omega_j)})$ of the article A_{ω_j} , and
- ω_j is in the set of hyperlinked phrases of the "definition" $(\Lambda^A_{(\omega_i)})$ of the article A_{ω_i}

<u>Definition 3</u>: $\delta_{\omega_i \to \omega_j} \coloneqq 2$ if the following conditions are met:

- ω_i appears in the set of phrases of the "information box" ($\eta_{(\omega_j)}^{B}$) of the article A_{ω_j} , and
- ω_j is in the set of hyperlinked phrases of the "information box" $(\Lambda^B_{(\omega_i)})$ of the article A_{ω_i}

<u>Definition 4</u>: $\delta_{\omega_i \to \omega_j} \coloneqq 3$ if the following conditions are met:

- ω_i appears in the set of phrases of the "description" ($\eta_{(\omega_j)}^C$) of the article A_{ω_j} , and
- ω_j is in the set of hyperlinked phrases of the "definition" $(\Lambda^A_{(\omega_i)})$ of the article A_{ω_i}

<u>Definition 5</u>: $\delta_{\omega_i \to \omega_j} \coloneqq 4$ if the following conditions are met:

- ω_i appears in the set of phrases of the "description" $(\eta_{(\omega_j)}^c)$ of the article A_{ω_j} , and
- ω_j is in the set of hyperlinked phrases of the "information box" $(\Lambda^{B}_{(\omega_i)})$ of the article A_{ω_i} **Definition 6**: $\delta_{\omega_i \to \omega_j} \coloneqq 5$ if the following conditions are met:
 - ω_i appears in the set of phrases of the "description" ($\eta_{(\omega_j)}^c$) of the article A_{ω_j} , and
 - ω_j is in the set of hyperlinked phrases of the "description" $(\Lambda^{C}_{(\omega_i)})$ of the article A_{ω_i}

<u>Definition 7</u>: $\delta_{\omega_i \to \omega_j} \coloneqq 6$ if the following conditions are met:

- ω_i appears in the set of phrases of the "summary of information" $(\eta_{(\omega_j)}^D)$ of the article A_{ω_j} , and $(\Lambda_{(\omega_j)}^A)$ of the article A_{ω_j} , and
- ω_j is in the set of hyperlinked phrases of the "definition" $(\Lambda^A_{(\omega_i)})$ of the article A_{ω_i}

<u>Definition 8</u>: $\delta_{\omega_i \to \omega_j} \coloneqq 7$ if the following conditions are met:

ω_i appears in the set of phrases of the "summary of information" (η^D_(ω_j)) of the article A_{ω_j}, and
 ω_j is in the set of hyperlinked phrases of the "information box" (Λ^B_(ω_i)) of the article A_{ω_i}

• Is in the set of hyperiniked phrases of the information box of the artic

<u>Definition 9</u>: $\delta_{\omega_i \to \omega_j} \coloneqq 8$ if the following conditions are met:

- ω_i appears in the set of phrases of the "summary of information" $(\eta_{(\omega_j)}^D)$ of article A_{ω_j} , and
- ω_j is in the set of hyperlinked phrases of the "description" $(\Lambda^{C}_{(\omega_i)})$ of article A_{ω_i}

<u>Definition 10</u>: $\delta_{\omega_i \to \omega_j} \coloneqq 9$ if the following conditions are met:

- ω_i does not exist in any of the sets $\eta^A_{(\omega_j)}$, $\eta^B_{(\omega_j)}$, or $\eta^C_{(\omega_j)}$ of the article A_{ω_j} ,
- ω_{j} is in the set of hyperlinked phrases $\Lambda^{A}_{(\omega_{i})}$, $\Lambda^{B}_{(\omega_{i})}$, or $\Lambda^{C}_{(\omega_{i})}$ of the article $A_{\omega_{i}}$, and
- ω_j is in the set of phrases of "categories" ($\eta_{(\omega_j)}^E$) of the article A_{ω_i}

<u>Definition 11</u>: $\delta_{\omega_i \to \omega_j} \coloneqq 10$ if the following conditions are met:

- ω_i appears in the set of phrases of the "summary of information" $(\eta_{(\omega_j)}^D)$ of article A_{ω_j} , and
- ω_j is in the set of hyperlinked phrases of the "summary of information" $(\Lambda^D_{(\omega_i)})$ of article A_{ω_i}

<u>Definition 12</u>: $\delta_{\omega_i \to \omega_j} \coloneqq 11$ if the following conditions are met:

- ω_i does not exist in any of the sets $\eta^A_{(\omega_j)}$ of the article A_{ω_j} ,
- ω_j is in the set of hyperlinked phrases $\Lambda^{\mathcal{B}}_{(\omega_i)}$ of the article A_{ω_i} , and

<u>Definition 13</u>: $\delta_{\omega_i \to \omega_j} := 12$ if the following conditions are met:

- ω_i does not exist in any of the sets $\eta^{\scriptscriptstyle B}_{(\omega_j)}$ of the article A_{ω_j} ,
- ω_j is in the set of hyperlinked phrases $\Lambda^{B}_{(\omega_i)}$ of the article A_{ω_i} , and

Definition 14: $\delta_{\omega_i \to \omega_j} \coloneqq 13$ if the following conditions are met:

- ω_i does not exist in any of the sets $\eta_{(\omega_j)}^c$ of the article A_{ω_j} ,
- ω_j is in the set of hyperlinked phrases $\Lambda^{c}_{(\omega_i)}$ of the article A_{ω_i} , and

Definition 15: $\delta_{\omega_i \to \omega_j} \coloneqq 14$ if the following conditions are met:

- ω_i does not exist in any of the sets $\eta^D_{(\omega_j)}$ of the article A_{ω_j} ,
- ω_j is in the set of hyperlinked phrases $\Lambda^{D}_{(\omega_i)}$ of the article A_{ω_i} , and

We define areas 0 to 14 ($\overset{0}{\Omega}_{(\omega)}, \overset{1}{\Omega}_{(\omega)}, \overset{2}{\Omega}_{(\omega)}, \square, \overset{14}{\Omega}_{(\omega)}$) to be the sets of phrases relevant to the phrase ω at distances 0 to 14.

$$\left(\overset{0}{\Omega}_{(\omega)} \cup \overset{1}{\Omega}_{(\omega)} \cup \overset{3}{\Omega}_{(\omega)} \cup \overset{6}{\Omega}_{(\omega)} \cup \overset{11}{\Omega}_{(\omega)} \right) \subseteq \Lambda^{\mathcal{A}}_{(\omega)}$$

$$\begin{pmatrix} 2 \\ \Omega_{(\omega)} \cup \Omega_{(\omega)}^{4} \cup \Omega_{(\omega)}^{7} \cup \Omega_{(\omega)}^{12} \end{pmatrix} \subseteq \Lambda_{(\omega)}^{B} \\ \begin{pmatrix} 5 \\ \Omega_{(\omega)} \cup \Omega_{(\omega)}^{8} \cup \Omega_{(\omega)}^{13} \end{pmatrix} \subseteq \Lambda_{(\omega)}^{C} \\ \begin{pmatrix} 10 \\ \Omega_{(\omega)} \cup \Omega_{(\omega)}^{14} \end{pmatrix} \subseteq \Lambda_{(\omega)}^{D} \\ \begin{pmatrix} 9 \\ \Omega_{(\omega)} \subseteq \left(\Lambda_{(\omega)}^{A} \cup \Lambda_{(\omega)}^{B} \cup \Lambda_{(\omega)}^{C} \right) \end{pmatrix}$$

While phrases at distances 0 to 6 are assumed to be relevant to ω , there exist some phrases at distances 7 to 14 that are not. Thus, phrases in areas 7 to 14 shall go through a phase of further relevancy testing that can be summarized as follows.

For each phrase $\alpha_{(\omega)}$ in the areas (i.e. at distance) 7 to 14, if the number of phrases (in areas 0 to 13) matching in articles $A_{\alpha_{(\omega)}}$ is above a certain threshold T, then, $\alpha_{(\omega)}$ is considered relevant to ω .

$$\forall \alpha \in \widehat{\Omega}_{(\omega)}^{n}, 7 \le n \le 14,$$

 $\alpha \text{ is relevant to } \omega \text{ if and only if } \left| \eta_{(\alpha)} \cap \left(\prod_{i=0}^{13} \widehat{\Omega}_{(\omega)}^{i} \right) \right| > T$
where $T = f(i, n, m)$ and $m = \left| \prod_{n=7}^{14} \widehat{\Omega}_{(\omega)} \right|$

Once all the definitions are applied to a Wikipedia article, a phrase fingerprint is generated (Figure 5).

1.2.5.1.3 Examples

Example 1: The word "iPhone" is in the set of hyperlinked phrases of the "definition" section $(\Lambda^{A}_{(Apple Inc.)})$ for the article $A_{Apple Inc.}$ describing "Apple Inc." (Figure 7). Also, the phrase "Apple Inc." appears in the set of phrases of the "definition" section $(\eta^{A}_{(iPhone)})$ for the article A_{iPhone} describing "iPhone" (Figure 8). We can conclude that the distance between the two phrases "Apple Inc." and "iPhone" is zero as per definition 1.

$$\delta_{_{Apple\,Inc.\,
ightarrow\,iPhone}}\coloneqq 0$$

Example 2: The phrase "Personal computer" is in the set of hyperlinked phrases of the "definition" section $(\Lambda^{A}_{(Apple Inc.)})$ for the article $A_{Apple Inc.}$ describing "Apple Inc." (Figure 7). Also, the alias of the

phrase "Apple Inc." appears in the set of phrases of the "description" section ($\eta^{C}_{(Personal \ computer})$) for the article $A_{Personal \ computer}$ describing "Personal computer" (Figure 9). We can conclude that the distance from "Apple Inc." to "Personal computer" is three as per definition 4.

$$\delta_{Apple Inc. \rightarrow Personal \ computer} \coloneqq 3$$

Example 3: The phrase "Computer software" is in the set of hyperlinked phrases of the "definition" section $(\Lambda^{A}_{(Apple Inc.)})$ for the article $A_{Apple Inc.}$ describing "Apple Inc." (Figure 7). Also, the alias of the phrase "Apple Inc." appears in the set of phrases of the "description" section $(\eta^{C}_{(Computer software)})$ for the article $A_{Computer software}$ describing "Computer software" (Figure 10). We can conclude that the distance from "Apple Inc." to "Computer software" is six as per definition 7.

$$\delta_{Apple Inc. \to Computer software} \coloneqq 6$$

Example 4: The phrase "Apple Inc." is in the set of hyperlinked phrases of the "definition" section $(\Lambda^{A}_{(Steve Jobs)})$ for the article $A_{Steve Jobs}$ describing "Steve Jobs" (Figure 11). Also, the phrase "Steve Jobs" appears in the set of phrases of the "information box" section $(\eta^{B}_{(Apple Inc.)})$ for the article $A_{Apple Inc.}$ describing "Apple Inc." (Figure 7). We can conclude that the distance from "Steve Jobs" to "Apple Inc." is one as per definition 2.

$$\delta_{\textit{Steve Jobs} \rightarrow \textit{Apple Inc.}} \coloneqq 1 \qquad \Longleftrightarrow \qquad \delta_{\textit{Apple Inc.} \rightarrow \textit{Steve Jobs}} \coloneqq -1$$

1.3 nanobird Phrase Tokenizer

1.3.1 Definition

The nanobird Phrase Tokenizer is responsible for splitting an inputted text into sets of phrases. The tokenizer dissects an inputted text and generates three different sets of phrases S_U, S_A, S_L . The phrases in those sets consist of longest exact matches found in any of the unambiguous phrase, ambiguous phrase, or phrase aliases dictionaries (D_U, D_A, D_L). Those sets are, at a later stage, used by the *nanobird Context Analyzer* (as depicted in Figure 13) to analyze the relation among phrases in those sets and study

their contextual correlation.

1.3.2 Algorithm

An inputted text is first split into an ordered set of words S_0 using the space character as a divider between different words.

The *nanobird Phrase Tokenizer*'s algorithm starts by forming a phrase P from the first word ω_1 , located at position i, in the ordered set of words S_o :

$$i \leftarrow 1$$
, $P \leftarrow \omega_i$, $\omega_i \in S_o$

The phrase P is tested against the following four conditions and different actions are taken.

Condition 1: if an exact match of P is found in any of the dictionaries D_U, D_A, D_L , then the phrase is temporarily saved for future use ($P_{saved} \leftarrow P$) and the position of the last word used is temporarily saved in i_{saved} , i.e. $i_{saved} \leftarrow i$. Moreover, a new phrase ($P \leftarrow P \oplus \omega_{i+1}$) is formed by concatenating the next word ω_{i+1} with the current phrase P. The new phrase is then tested again against the four conditions.

Condition 2: if a submatch of P is found in any of the dictionaries D_U, D_A, D_L , then a new phrase ($P \leftarrow P \oplus \omega_{i+1}$) is formed by concatenating the next word ω_{i+1} with the current phrase P. The new phrase is then tested again against the four conditions. The position of the next word to continue processing from becomes $i \leftarrow i+1$

Condition 3: if neither an exact match nor a submatch of P is found in any of the dictionaries D_U, D_A, D_L and there exists a temporarily saved phrase P_{saved} (as described in condition 1) such that $P_{saved} \neq \emptyset$, then P_{saved} is considered to be the longest matching phrase found in any of the dictionaries D_U, D_A, D_L and thus, is added to one of sets of phrases S_U , S_A , or S_L depending on whether the exact match was found in D_U , D_A , or D_L respectively.

$$P_{saved} \in D_U \implies S_U \leftarrow S_U \cup \{P_{saved}\}$$
$$P_{saved} \in D_A \implies S_A \leftarrow S_A \cup \{P_{saved}\}$$
$$P_{saved} \in D_L \implies S_L \leftarrow S_L \cup \{P_{saved}\}$$

At this point, more actions are taken:

- P_{saved} is deleted ($P_{saved} \leftarrow \emptyset$)
- The position of the next word to continue processing from is learned ($i \leftarrow i_{saved} + 1$)
- The new phrase is now $P \leftarrow \omega_i$ and is tested against the four conditions.

Condition 4: if neither an exact match nor a submatch of P is found in any of the dictionaries (D_U, D_A, D_L) and there exists no temporarily saved phrase P_{saved} (as described in condition 1) that is $P_{saved} = \emptyset$ then:

- The position of the next word to continue processing from is learned ($i \leftarrow i_{saved} + 1$)
- The new phrase is now $P \leftarrow \omega_i$ and is tested against the four conditions. •

Figure 12 is a pseudo-code of the algorithm that extracts the sets of longest matching phrases.

1.3.3 Example

Consider the following given text:

"Steven Jobs requested that the Apple store on Chestnut Street in San Francisco be closed next Monday."

Also, assume the following predefined dictionaries:

 $D_U = \{$ Apple Store, San Francisco, San Francis, Steve Jobs, Apple store $\}$ $D_A = \{$ Apple, Chestnut, San, Monday $\}$ $D_L = \{$ Steven Jobs, Steven Paul Jobs $\}$

T he *nanobird Phrase Tokenizer* firsts generates the ordered set of words S_o from the above given text.

For instance, an inputted text shown in Figure 14 will generate the following ordered set of words.

 $S_{o} = \begin{cases} Steven, Jobs, requested, that, the, Apple, store, on, Chestnut, \\ Street, in, San, Francisco, be, closed, next, Monday. \end{cases}$

The tokenizer looks up the dictionaries D_U, D_A, D_L and finds a submatch in D_L . As per *condition 2*, a new phrase is formed by concatenating the next word with the current phrase. Thus,

 $P \leftarrow Steven Jobs$

The tokenizer looks up P in the dictionaries D_U, D_A, D_L and finds an exact match in D_L . As per *condition 1*, then the phrase is temporarily saved for future use and the position of the last word used is temporarily saved in i_{saved} . A new phrase is formed by concatenating the next word:

$$P_{saved} \leftarrow Steven Jobs$$
 $i_{saved} \leftarrow 2$

$P \leftarrow Steven Jobs requested$

The tokenizer looks up P in the dictionaries D_U, D_A, D_L and finds neither an exact match nor a submatch. Thus, as per *condition 3*, P_{saved} is considered to be the longest matching phrase found in dictionary D_L , and thus, is added to the set of phrases S_L .

$$P_{saved} \in D_L \implies S_L \leftarrow \{Steven Jobs\}$$

 P_{saved} is deleted.

$$P_{saved} \leftarrow \emptyset$$

The position of the next word to continue processing from is learned ($i \leftarrow i_{saved} + 1$)

 $i \leftarrow 3$

The new phrase is now:

 $P \leftarrow requested$

A new lookup is done on P in the dictionaries D_U, D_A, D_L and neither an exact match nor a submatch is found and there exists no temporarily saved phrase that is $P_{saved} = \emptyset$. As per **condition 4**, the position of the next word to continue processing from is learned ($i \leftarrow i_{saved} + 1$)

 $i \leftarrow 4$

The new phrase is now:

 $P \leftarrow that$

The processing of the text continues until the three sets S_U , S_A , S_L are extracted. For the above given text, the three generated sets are:

 $S_U = \{\text{Apple store, San Francisco} \}$ $S_A = \{\text{Chestnut, Monday}\}$ $S_L = \{\text{Steven Jobs} \}$

1.4 nanobird Context Analyzer

1.4.1 Definition

The *nanobird Context Analyzer* is responsible for generating the *nanobird Context Graph*, a graph depicting the relations between the different phrases extracted by the *nanobird Phrase Tokenizer*. The graph's vertices consist of phrases, while its edges represent the distances between phrases. By looking at the graph and the correlation between the different phrases extracted from a given text, it becomes possible to learn the most important phrases that describe/outline/summarize that given text.

1.4.2 Algorithm

The *nanobird Context Analyzer* takes, as an input, the sets of phrases S_U, S_A, S_L created by passing an inputted natural language data (text) to the *nanobird Phrase Tokenizer*.

Each phrase in each set is then filtered out when compared against the sets of keys of the stop phrases dictionary (K_{D_U}). Any phrase matching any of the keys in K_{D_U} is removed from the three sets. This results in new sets of phrases S'_U , S'_A , and S'_L .

The resulting set of ambiguous phrases (S'_A) is then converted into a set of unambiguous phrases (S^A_U) using dictionary D_A .

Similarly, the set of phrase aliases (S'_L) is then converted into a set of unambiguous phrases (S^L_U) using dictionary D_L . Then, the three sets of unambiguous phrases are merged into a single set S.

$$S = S_U^{'} \bigsqcup S_U^A \bigsqcup S_U^L$$

Every pair of phrases from the set S is looked up in the fingerprint dictionary D_F and the distance between the pair of phrases is extracted. Once all the distances are extracted between every pair of phrases, a graph is generated by the *nanobird Context Analyzer*. The *nanobird Context Analyzer* internal flowchart is shown in Figure 13.

1.4.3 Example

The following example goes step by step through this context analysis process.

An example of a natural language data is given in Figure 14. The three sets of phrases generated by passing the text through the *nanobird Phrase Tokenizer* (as described in section 1.3) are:

$$S_{U} = \{ \text{Climate change} \}$$

 $S_A = \{ atmosphere, Wednesday \}$

 $S_L = \{$ climate crisis, greenhouse gases, ecosystems $\}$

Assume the following to be a predefined stop phrases dictionary:

 $D_{S} = \{$ who, best, where, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday, once $\}$

The three sets are first filtered using the stop phrases dictionary D_s , yielding the following sets where the word "Wednesday" is omitted since it is part of stop phrases dictionary.

 $S'_{U} = \{ \text{Climate change} \}$

 $S'_{A} = \{ atmosphere \}$

 $S'_{L} = \{$ climate crisis, greenhouse gases, ecosystems $\}$

The new set $S_{A}^{'}$ is then transformed using dictionaries D_{A} (refer to Figure 3) into the set S_{A}^{U} . For instance, the word "*atmosphere*" is replaced with the phrases "*Atmosphere of Earth*", "*Atmosphere*",

"Extraterrestrial atmospheres", "Stellar atmosphere", "Gas", "Adobe Atmosphere", and "Atmosphere Visual Effects".

Similarly, the new set $S_{L}^{'}$ is then transformed using dictionaries D_{L} (refer to Figure 4) into the set S_{L}^{U} . For instance, the phrase "*climate crisis*" is replaced with the phrase "*Global warming*", while the phrase "*ecosystems*" is replaced with the phrase "*Ecosystem*".

The new resulting sets are thus:

 $S'_{II} = \{ \text{Climate change} \}$

 $S_A^U = \{ \text{Atmosphere of Earth, Atmosphere,} \square, \text{Adobe Atmosphere, Atmosphere Visual Effects} \}$

 $S_L^U = \{$ Global warming, Greenhouse gas, Ecosystem $\}$

The three sets of unambiguous phrases are merged into a single set S.

$$S = \begin{cases} Climate change, \\ Atmosphere of Earth, \\ Atmosphere, \\ \Box \\, \\ Adobe Atmosphere, \\ Atmosphere Visual Effects, \\ Global warming, \\ Greenhouse gas, \\ Ecosystem \\ \end{cases}$$

Using the dictionary of phrase fingerprints D_F , the phrases in the set S are correlated. Figure 15 depicts a fingerprint map of the phrase "Atmosphere of Earth". As shown in Figure 15, the phrase "Atmosphere of Earth" is related to the phrase "Climate change" positioned at a distance 10.

 $\delta_{\text{Atmosphere of Earth} \rightarrow \text{Climate change}} \coloneqq 10$

In Figure 16, a relation exists between the two words "Climate change" and "Global warming", such that:

$$\delta_{\text{Climate change} \rightarrow \text{Global warming}} \coloneqq -3 \Leftrightarrow \delta_{\text{Global warming} \rightarrow \text{Climate change}} \coloneqq 3$$

Similarly, the maps of phrase fingerprints depicted in Figure 17, Figure 18, and Figure 19 yield the following relations:

$$\delta_{\text{Ecosystem} \rightarrow \text{Global warming}} \coloneqq 10$$

 $\delta_{\text{Global warming} \rightarrow \text{Atmosphere}} \coloneqq 14$

 $\delta_{\text{Global warming} \rightarrow \text{Greenhouse gas}} \coloneqq 6$

 $\delta_{\text{Greenhouse gas} \rightarrow \text{Atmosphere of Earth}} \coloneqq 6$

On the other hand, no relations were found between the phrase "Adobe Atmosphere" and the other phrases of the set S. As a result, the phrase "Adobe Atmosphere" is discarded. Finally, a *nanobird* Context Graph is generated (Figure 20) showing only the phrases for which correlations with other phrases are found using the fingerprints. Those phrases describe/outline/summarize the natural language data of Figure 14.

2 nRE Applications

The application of nRE is very rich, ranging from profiling social media users to delivering tailored advertisements. The following sections summarize some of the applications where nRE could play a big part.

2.1 Twitter and Other Social Networking Sites

Pinpointing interests of social media (Facebook, Twitter, and Google+) users has been considered to be a very challenging problem. Using nRE, profiling users has been proven to be feasible. The solution opens the door to predicting what a user will want to read within their social media feeds and what news articles he/she will be interested in reading in the future.

A Twitter application using nRE has been developed where twitter accounts are processed and profiled. For each account, the last 100 tweets are collected and each tweet is passed to nRE to yield the set of phrases that best describe the tweets or the links within the tweets. Then, the occurrence of the same phrases in all the 100 sets (generated by all the tweets) is noted down and the phrases with the highest number of occurrences are deemed to represent the user's main interests. If a twitter user does not share links/tweets, the twitter accounts they are following are profiled and the user is considered to have the collective interests of the users he/she is following.

The nanobird twitter application is able to directly spot the interests of every single twitter user and recommend other twitter users sharing common interests (Figure 21). The application is also able to filter out the non-relevant links that are coming up in a user's feed. Massive amount of noise in users account could be turned into a fine tune or pitch of tweets/links that are relevant to the users' interests.

Similarly, the nanobird social media application profiles users on other social networking sites (e.g. Facebook, Google+) and determines their interest by processing the links and text they share.

2.2 News

The nanobird news application's main focus is on providing users with news tailored to their likings. The news application has three main components: a profiling component, a news context analyzer, a news delivery component.

- Profiling component: Learning a user's news interests could be achieved in two ways; either by conducting an initial profiling of the provided user's social media accounts, or by learning, over time, from the news the user reads on the nanobird news application. The latter learning technique is based on monitoring a user's reading behavior and some aging algorithms to clean out entities that are no longer relevant to a user and entities that were only part of a sudden world event or non-timeless event.
- News context analyzer: As fresh news articles are published, the nRE profiles every new article and extracts the set of words that best describes the article.
- News delivery component: By combining the results from the profiling component and the news context analyzer component, it becomes possible to deliver news closest to the users' interests.

2.3 Movie Recommendations

The nanobird movie application is an application that provides movie recommendation to users. It comprises two main components: an movie understanding component and recommendation component.

- Movie understanding component: Every film's plot synopsis and summary is passed through the nRE where the relevant entities of the movie are extracted and classified.
- Recommendations component: A user is asked to input a movie of their preference and the recommendation component provides him/her with the closest matching movie in terms of synopsis and/or genre such as "spy action thriller". The nanobird movie application will always recommend more recent films (including the latest films out on DVD, in theaters, or coming soon) before the outdated ones.

2.4 Book Suggestions

The nanobird book recommendation application is similar to the nanobird movie recommendations one except that the profiling of a book is achieved by passing the story plot/summary to the nRE.

2.5 Advertisement

The nanobird advertisement application helps content providers increase their revenue from advertisements by displaying relevant ads on their published sites. Relevant ads are displayed based on the site-visitor's interests (extracted from his/her social media accounts as previously described) or based on the content of the pages itself using nRE.

2.6 Search

By understanding text just as a human does, the nanobird search application is able to organize all the content of the web just as a human would organize documents in a ling cabinet based on subject. A nanobird search application would be able to give search results based on relevancy to what a user searches for. The nanobird search application could be a plug-in to search engines such as Google and Bing to improve ranking of results and results classification.



Figure 1. The nanobird Relevancy Engine Components Diagram



Figure 2. A subset of the unambiguous phrases dictionary







Figure 4. An example of phrase aliases and their mapping to unambiguous phrases



Figure 5. A fingerprint of the phrase "Apple Inc."

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| The Apple II was introduced on April 16, 1977 at the first West Coast Computer Faire. It differed from its major rivals, the TRS-80 and Commodore PET, because it came with color graphics and an pen architecture. While early models used ordinary cassett tapes as storage devices, they were superseded by the introduction of a 5 1/4 inch floppy disk drive and interface, the Disk II ²⁶¹ and gate home tasks chosen to be the desktop platform for the first "killer apy" of the business word—the VisiCalc spreadsheet program. ^[29] VisiCalc created a business market for the Apple II, and gate home tasks and the distore to be the desktop platform for the first "killer apy" of the business word—the VisiCalc spreadsheet program. ^[29] VisiCalc created a business market for the Apple II, and gate home tasks for the Apple II and gate home tasks for the Apple II and gate home tasks for computer designers and a no group task drive and market. ^[29] According to Brian Bagnall, Apple exaggerated its sales figures and was a distant third place to Commodore and Tany until VisiCalc carne along. ^[300] Apple had a staff of computer designers and a production line. The company introduced the ill-fated Apple III in May 1980 in an attempt to compete with IBM and Microsoft in the business and comported computing market. ^[30] Jobs was immediately comined that all future computers would use a graphical user interface (GU), and development of a GU began for the Apple Lisa. ^[31] Jobs was immediately comined that all future computers would use a graphical user interface. ³¹ Bis 1-931 Jobs was immediately comined that all future computers project, the Macintosh. At tur was broke out the Apple Lisa in 1978 but in 1982 he was pushed from the Lisa team due to infighting, and took over Jef Raskin's low-cost-computer project, the Macintosh. At tur was broke out the front was companies of the United States Nome organies of the United States Nome organies of the United States Nome organies of the United States Not units and to the organie | Apple was incorporated January 3, 1977 ^[7] funding of \$250,000 during the incorporati | without Wayne, who sold his share of the con on of Apple. ^{[26][27]} | npany back to Jobs and Wozniak for \$800. Multi- | nillionaire Mike Markkula provided essential busine | s expertise and | Headquarters | Apple Campus |
| The Apple II was chosen to be the desktop platform for the first "killer app" of the business world—the VisiCalc spreadsheet program [^{29]} VisiCalc created a business market for the Apple II, and gave home users an additional reason to buy an Apple II—compatibility with the office [^{29]} According to Brian Bagnall, Apple exaggerated its sales figures and was a distant third place to Commodore and Tanay until VisiCalc came along ^[30] 31] By the end of the 1970s, Apple had a staff of computer designers and a production line. The company introduced the iII-fated Apple III in May 1980 in an attempt to compete with IBM and Microsoft in the business and corporate computing market. ^[32] Jobs and several Apple employees including Jef Raskin visited Xerox PARC in December 1979 to see the Xerox Alto. Xerox granted Apple engineers three days of access to the PARC facilities in return for the option to buy 100,000 sphra-djusted shares) of Apple at the pre-IPO price of \$10 a share. ^[33] Jobs was immediately convinced that all future computers would use a graphical user interface (GUD), and development of a GUI began for the Apple Lisa. ^[34] VisiCalc for allowing on the Apple Lisa for the Apple Lisa. ^[34] Vise Apple St. Lisa and Macintosh Steve Jobs began working on the Apple Lisa in 1978 but in 1982 he was pushed from the Lisa team due to infighting, and took over Jef Raskin's low-cost-computer project, the Macintosh. A turf war broke out Categories: Companies listed on NASDAQ Companies in the NASDAQ-100 Index 1976 establishments in the United States Apple Inc. Companies Bectronics companies Electronics companie | The Apple II was introduced on April 16, 1 architecture. While early models used or | 977 at the first West Coast Computer Faire. It linary cassette tapes as storage devices, they | differed from its major rivals, the TRS-80 and Corr were superseded by the introduction of a 5 1/4 inc | modore PET, because it came with color graphics a ch floppy disk drive and interface, the Disk II. ^[28] | nd an ppen | Number of | Cupertino, California, U.S. 317 retail stores |
| VisiCalc came along. ^{[30[31]} By the end of the 1970s, Apple had a staff of computer designers and a production line. The company introduced the ill-fated Apple III in May 1980 in an attempt to compete with IBM and Microsoft in the business and corporate computing market. ^[32] Jobs and several Apple employees including Jef Raskin visited Xerox PARC in December 1979 to see the Xerox Alto. Xerox granted Apple engineers three days of access to the PARC facilities in return for the option to buy 100,000 shares (800,000 split-adjusted shares) of Apple at the pre-IPO price of \$10 a share. ^[33] Jobs was immediately convinced that all future computers would use a graphical user interface [60,000 split-adjusted shares) of Apple at the pre-IPO price of \$10 a share. ^[33] Jobs was immediately convinced that all future computers would use a graphical user interface [60,000 split-adjusted shares) of Apple at the pre-IPO price of \$10 a share. ^[33] Jobs was immediately convinced that all future computers would use a graphical user interface [60,000 split-adjusted shares) of Apple at the pre-IPO price of \$10 a share. ^[33] Jobs was immediately convinced that all future computers would use a graphical user interface [60,000 split-adjusted shares] of Apple at the pre-IPO price of \$10 a share. ^[33] Jobs was immediately convinced that all future computers would use a graphical user interface [60,000 split-adjusted shares] of Apple at the pre-IPO price of \$10 a share. ^[33] Jobs was immediately convinced that all future computers would use a graphical user interface [60,000 split-adjusted shares] of Apple at the pre-IPO price of \$10 a share. ^[33] Jobs was immediately convinced that all future computers would use a graphical user interface [60,000 split-adjusted shares] of Apple at the pre-IPO split adjusted shares] of Apple at the pre-IPO split adjusted shares] adjusted shares | The Apple II was chosen to be the deskto users an additional reason to buy an Appl | p platform for the first "killer app" of the busines le II—compatibility with the office. ^[29] According | s world—the VisiCalc spreadsheet program. ^[29] to Brian Bagnall, Apple exaggerated its sales fig | /isiCalc created a business market for the Apple II, ures and was a distant third place to Commodore a | and gave home id Tandy until | locations Area served | (as of October 2010) ^[2] VVorldwide |
| business and corporate computing market. ^[32] Jobs and several Apple employees including. Jef Raskin visited Xerox PARC in December 1979 to see the Xerox Alto. Xerox granted Apple engineers three days of access to the PARC facilities in return for the option to buy 100,000 shares (600,000 split-adjusted shares) of Apple at the pre-IPO price of \$10 a share. ^[33] Jobs was immediately convinced that all future computers would use a graphical user interface [G(U)], and development of a GUI began for the Apple Lisa. ^[34] When Apple went public, it generated more capital than any IPO since Ford Motor Company in 1956 and instantly created more millionaires (about 300) than any company in history. [1981–1985: Lisa and Macintosh Steve Jobs began working on the Apple Lisa in 1978 but in 1982 he was pushed from the Lisa team due to infighting, and took over Jef Raskin's low-cost-computer project, the Macintosh. A turf was broke out [1972] Categories: Companies listed on NASDAQ Companies in the NASDAQ-100 Index 1976 establishments in the United States Apple Inc. Companies based in Cupertino, California Companies established in 1976 [200] Companies of the United States Networking hardware companies Display technology companies Electronics companies of the United States Apple Inc. Companies Electronics companies Electro | VisiCalc came along. ^{[30][31]} By the end of the 1970s, Apple had a stat | ff of computer designers and a production line. | The company introduced the ill-fated Apple III in M | lay 1980 in an attempt to compete with IBM and Mi | rosoft in the | Key people | Tim Cook (CEO) Steve Jobs (Chairman) |
| Jobs and several Apple employees including. Jef Raskin visited Xerox PARC in December 1979 to see the Xerox Alto. Xerox granted Apple engineers three days of access to the PARC facilities in feturm for the J products in terms of Apple at the pre-IPO price of \$10 a share.] ^{(33]} Jobs was immediately convinced that all future computers would use a graphical user in feture of a GUI began for the Apple Lisa.] ^{(34]} Products in the pre-IPO price of \$10 a share.] ^{(33]} Jobs was immediately convinced that all future computers would use a graphical user in terface Products in terface Products in terface Services Services is the part [above] (GUI), and development of a GUI began for the Apple Lisa.] ^{(34]} When Apple went public, it generated more capital than any IPO since Ford Motor Company in 1956 and instantly created more millionaires (about 300) than any company in history. If Revenue US\$ 65.23 billion (FY 2010) ^[21] 1981–1985: Lisa and Macintosh Steve Jobs began working on the Apple Lisa in 1978 but in 1982 he was pushed from the Lisa team due to infighting, and took over Jef Raskin's low-cost-computer project, the Macintosh. A turf was broke out Profit US\$ 14.01 billion (FY 2010) ^[21] Categories: Companies listed on NASDAQ. Companies in the NASDAQ-100 Index 1976 establishments in the United States Apple Inc. Companies based in Cupertino, California Companies established in 1976 Comparies of the United States Computer companies of the United States Computer hardware companies Mobile phone manufacturers Mobile phone manufacturers Mobile pho | business and corporate computing marke | t. ^[32] | | | | i | Senior Vice Presidents [show] |
| (GUI), and development of a CUI began for the Apple Lisa. ^[50] When Apple went public, it generated more capital than any IPO since Ford Motor Company in 1956 and instantly created more millionaires (about 300) than any company in history. 1981–1985: Lisa and Macintosh Steve Jobs began working on the Apple Lisa in 1978 but in 1982 he was pushed from the Lisa team due to infighting, and took over Jef Raskin's low-cost-computer project, the Macintosh. A turf wai broke out Profit US\$ 16.39 billion (#Y 2010) ^[21] Categories: Companies listed on NASDAQ Companies in the NASDAQ-100 Index 1976 establishments in the United States Apple Inc. Companies based in Cupertino, California Companies established in 1976 Computer companies of the United States Computer hardware companies Display technology companies Electronics companies of the United States Networking hardware companies Portable audio player manufacturers Publicly traded companies Electronics companies of the United States Steve Jobs Warrants issued in Hong Kong Stock Exchange | Jobs and several Apple employees includ option to buy 100,000 shares (800,000 sp | ing Jef Raskin visited Xerox PARC in Decembe lit-adjusted shares) of Apple at the pre-IPO pric | r 1979 to see the Xerox Alto. Xerox granted Apple e of \$10 a share. ^[33] Jobs was immediately convi | engineers three days of access to the PARC facilit need that all future computers would use a graphica | es in return for the user interface | Products | Products list [show] |
| 1981–1985: Lisa and Macintosh Steve Jobs began working on the Apple Lisa in 1978 but in 1982 he was pushed from the Lisa team due to infighting, and took over Jef Raskin's low-cost-computer project, the Macintosh. A turf was US\$ 18.39 billion (FY 2010) ^[21] Categories: Companies listed on NASDAQ Companies in the NASDAQ-100 Index 1976 establishments in the United States Apple Inc. Companies based in Cupertino, California Companies established in 1976 US\$ 14.01 billion (FY 2010) ^[21] Categories: Companies of the United States Computer companies Display technology companies Electronics companies of the United States Networking hardware companies Portable audio player manufacturers Publicly traded companies Electronics companies Retail companies of the United States Steve Jobs Warrants issued in Hong Kong Stock Exchange | (GUI), and development of a GUI began to When Apple went public, it generated mo | r the Apple Lisa. ¹⁹⁴¹ re capital than any IPO since Ford Motor Comr | any in 1956 and instantly created more millionair | es (about 300) than any company in history | | Revenue | LUS\$ 65.23 billion (FY 2010) ^[2] |
| Steve Jobs began working on the Apple Lisa in 1978 but in 1982 he was pushed from the Lisa team due to infighting, and took over Jef Raskin's low-cost-computer project, the Macintosh. A turf was broke out Profit AUS\$ 14.01 billion (FY 2010) ^[21] Categories: Companies listed on NASDAQ Companies in the NASDAQ-100 Index 1976 establishments in the United States Apple Inc. Companies based in Cupertino, California Companies established in 1976 Computer companies of the United States Computer hardware companies Display technology companies Electronics companies of the United States Home computer hardware companies Mobile phone manufacturers Multinational companies of the United States Steve Jobs Warrants issued in Hong Kong Stock Exchange | 1981-1985: Liss and Macintosh | | | ee (about booy man any company in motory. | | Operating | ▲ US\$ 18.39 billion (FY 2010) ^[2] |
| Categories: Companies listed on NASDAQ Companies in the NASDAQ-100 Index 1976 establishments in the United States Apple Inc. Companies based in Cupertino, California Companies established in 1976 Computer companies of the United States Computer hardware companies Display technology companies Electronics companies of the United States Home computer hardware companies Mobile phone manufacturers Multinational companies headquartered in the United States Networking hardware companies Portable audio player manufacturers Publicly traded companies Electronics companies Retail companies of the United States Steve Jobs Warrants issued in Hong Kong Stock Exchange | Steve Jobs began working on the Apple L | isa in 1978 but in 1982 he was pushed from the | Lisa team due to infighting, and took over Jef Ra | skin's low-cost-computer project, the Macintosh. A | urf war broke out | Profit | US\$ 14.01 billion (FY 2010) ^[2] |
| Categones: Companies listed on NASDAU Companies in the NASDAU-IUU Index 1976 establishments in the United States Apple Inc. Companies based in Cupertino, California Companies established in 1976 Computer companies of the United States Computer hardware companies Display technology companies Electronics companies of the United States Home computer hardware companies Mobile phone manufacturers Multinational companies headquartered in the United States Networking hardware companies Portable audio player manufacturers Publicly traded companies Electronics companies Retail companies of the United States Software companies of the United States Steve Jobs Warrants issued in Hong Kong Stock Exchange | (| | | | | | \ |
| Multinational companies headquartered in the United States Networking hardware companies Portable audio player manufacturers Publicly traded companies Electronics companies Retail companies of the United States Software companies Software companies of the United States Software companies Software companies of the United States Software companies Software companie | Categories: Companies listed on NASDA | es Companies in the NASDAG-100 Index | 1976 establishments in the United States Appl technology companies Electronics companies | e Inc. Companies based in Cupertino, California s of the United States Home computer hardware i | companies estab | lished in 1976 e phone manufac | turers |
| Software companies of the United States Steve Jobs Warrants issued in Hong Kong Stock Exchange | Multinational companies headquartered | in the United States Networking hardware co | mpanies Portable audio player manufacturers | Publicly traded companies Electronics companies | ies Retail compa | inies of the Unite | d States |
| | Software companies of the United State | s Steve Jobs Warrants issued in Hong Ko | ng Stock Exchange | | | | j |

Figure 6. A Wikipedia article split into five defined sections



Figure 7. A Wikipedia article about "Apple Inc."

| | η <mark>Α</mark> (iPhone) | $\eta^{C}_{(iPhone)}$ | $\eta^{D}_{(iPhone)}$ | $\eta^{\mathbf{B}}_{(\mathrm{iPhone})}$ |
|--|--|--|--|--|
| (Phone) | | | | |
| From Wikipedia, the free encyclopedia (Redirected from lphone) | | | | |
| This article is about the line of smartphones designed by Apple. | For other uses, see iPhone (disamb | liguation). | | _ \ |
| The iPhone (pronounced <i>l'atfount Eve-folm</i>) is a line of Internet and 2007, ^[1] and released on June 29, 2007. The 5th generation iPhone, to operating system for handheld devices. | multimedia-enabled smartphones ma the iPhone 4S, was announced on Oc | arke ed by <u>Apple Inc.</u> . The first iPhone was unveiled by fo ctober 4, 2011, and released on October 14, 2011, two d | ormer Apple CEO Steve Jobs on January 9, ays after the release of iOS 5.0, the Apple | |
| An iPhone can function as a video camera (video recording was not a browsing capabilities, can send texts and receive visual voicemail, ar than a physical one. Third-party as well as Apple application softwar functions, including games, reference, GPS navigation, social networ | a standard feature until the iPhone 3G nd has both Wi-Fi and 3G connectivity e is available from the App Store, whi rking, security and advertising for tele | S was released), a camera phone, a portable media play y. The user interface is built around the device's multi-tou ch launched in mid-2008 and now has over 500,000 ^[2] "ay vision shows, films, and celebrities. | yer, and an internet client with email and web ich screen, including a virtual keyboard rather pps" approved by Apple. These apps have diverse | |
| There are five generations of iPhone models, each accompanied by or screen size and button placement that have persisted through all mor higher resolution camera, including video recording at 480p. The iPhot apps like Skype. The iPhone 4 featured a higher-resolution 960x640 the iPhone 4 launched for Verizon. On October 4, 2011, Apple annou stabilization, a faster, dual core processor, world phone capability (a system called Siri. ^[4] It will be available in 16 GB and 32 GB as well. <u>Wireless announced that it would be carrying the iPhone 4S as well</u> . | one of the five major releases of iOS () dels. The iPhone 3G added 3G cellul one 4 has a rear facing camera (720p display; it was released on June 24, 2 unced the iPhone 4S, ^[3] The iPhone 4 llowing a single handset to operate or as a new 64 GB capacity. It was also [5] | formerly iPhone OS). The original iPhone was a GSM ph ar network capabilities and A-GPS location. The iPhone video) and a front facing camera (at a lower resolution) fo 2010. In the U.S., AT&T was the only authorized carrier of S added a higher resolution camera (8 megapixel) with 1 n networks based on both GSM/UMTS and CDMA techni announced that in the U.S. Sprint would begin carrying | one that established design precedents like 3GS added a compass, faster processor, and pr FaceTime video calling and for use in other until Februaly 10, 2011, when a CDMA version of 080p video recording, face detection, and video logies), and a natural language voice control the iPhone 4 and iPhone 4S and C Spire | |
| History and availability | | | [edit] | |
| Main article: History of the iPhone See also: List of iOS devices | | | | • |
| Development of the iPhone began in 2005 with Apple CEO Steve Job A phone, ^[7] Apple created the device during a secretive collaboration | s' direction that Apple engineers inve with <u>AT&T Mobility</u> _Cingular_Wireles | stigate touchscreens. ⁽⁶⁾ He also steered the original focu as at the time <u>—at an estimated development cost of US</u> | us away from a tablet, like the iPad, and towards 150 million over thirty months. ¹⁸¹ Apple rejected. | The iPhone 4S, the most recent generation of the iPhone |

Figure 8. A Wikipedia article about "iPhone"

| $\eta^{\mathbf{A}}_{(\text{Personal computer})}$ $\eta^{\mathbf{C}}_{(\text{Personal computer})}$ | $\eta^{\mathbf{B}}_{(\operatorname{Personal computer})}$ | | | |
|---|--|--|--|--|
| (Personal computer) | | | | |
| From Wikipedia, the free encyclopedia (Redirected from Personal computers) | | | | |
| This article is about personal competers in general. For computers generally referred to as "PCs", see IBM PC compatible. For hardware components dealing with personal computers, see Personal com | puter hardwere. | | | |
| A personal computer (PC) is any general-purpose computer whose size, capabilities, and original sales price make it useful for individuals, and which is intended to be operated directly by an end-user with no intervening computer operator. In contrast, the batch processing or time-sharing models allowed large expensive mainframe systems to be used by many people, usually at the same time. Large data processing systems require a full-time staff to operate efficiently. | Personal computer | | | |
| Software applications for personal computers include, but are not limited to, word processing, spreadsheets, databases, Web browsers and e-mail clients, digital media playback, games, and myriad personal productivity and special-purpose software applications. Modern personal computers often have connections to the Internet, allowing access to the World Wide Web and a wide range of other resources. Personal computers may be connected to a local area network (LAN), either by a cable or a wireless connection. A personal computer may be a desktop computer or a laptop, tablet PC, or a handheld PC. | | | | |
| While early PC owners usually had to write their own programs to do anything useful with the machines, today's users have access to a wide range of commercial software and free software, which is provided in ready-to-compile form. Since the early 1990s, Microsoft and Intel have dominated much of the personal computer market, first with MS-DOS and then with the Wintel platform. Alternatives to Windows include <u>Apple's</u> Mac OSX and the open-source Linux OSes. AMD is the major alternative to Intel. Applications and games for PCs are typically developed and distributed independently from the hardware on <u>Semanticat</u> thers, whereas software for many mobile phones and other portable systems is approved and distributed through a centralized online store. ^{[1][2]} | | | | |
| In July and August 2011, mark ting businesses and journalists began to talk about the 'Post-PC Era', in which the desktop form factor was being replaced with more portable computing such as netbooks, Tablet PCs, and smartphones. ^[3] | | | | |

Figure 9. A Wikipedia article about "Personal computer"

 $\eta^A_{(\text{Computer software})} \qquad \eta^D_{(\text{Computer software})}$

Computer software

"Software" redirects here. For other uses, see Software (disambiguation

Computer software, or just software, is a collection of computer program, and related data that provide the instructions for telling a computer what to do and how to do it. In other words, software is a conceptual entity which is a set of computer program, procedures, and associated documentation concerned with the oberation of a data processing system. We can also say software refers to one or more computer programs and data held in the storage of the computer for some purposes. In other words software is a set of programs, procedures, algorithms and its documentation. Program software performs the function of the program it implements, either by directly providing instructions to the computer hardware or by serving as input to another piece of software. The term was coined to contrast to the old term hardware (meaning physical devices). In contrast to hardware, software is intangible, meaning it "cannot be touched".^[1] Software is also sometimes used in a more narrow serving application software only. Sometimes the term includes data that has not traditionally been associated with computers, such as film, tapes, and records.^[2]

History

For the history prior to 1946, see History of computing hardware.

The first theory about software was proposed by Alan Turing in his 1935 essay *Computable numbers with an application to the Entscheidungsproblem (Decision problem)*^[8] The term "software" was first used in print by John W. Tukey in 1958.^[4] Colloquially, the term is often used to mean application software. In computer science and software engineering, software is all information processed by computer system, programs and data.^[4] The academic fields studying software are computer science and software engineering.

The history of computer software is most often traced back to the first software bug in 1946^{Eritation reveded}. As more and more programs enter the realm of firmware, and the hardware itself becomes smaller, cheaper and faster as predicted by Moore's law, leterents of computing first considered to be software, join the ranks of hardware. Most hardware companies today have more software programmers on the payroll than hardware designers^[Eritation meeded], since software tools have automated many tasks of Printed circuit board engineers. Just like the Auto industry, the Software industry has grown from a few visionaries operating out of their garage with prototypes. Steve Jobs and Bill Gates were the Henry Ford and Louis Chevrolet of their times^[Eritation meeded], who capitalized on ideas already commonly known before they started in the business. In the case of Software development, this moment is generally agreed to be the publication in the 1980s of the specifications for the IBM Personal Computer published by IBM employee Philip Don Estridge. Today his move would be seen as a type of crowd-sourcing.

Until that time, software was *bundled* with the hardware by Original equipment manufacturers (OEMs) such as Data General, Digital Equipment and IBM^{Eitation reeded}]. When a customer bought a minicomputer, at that time the smallest computer on the market, the computer did not come with Pre-installed software, but needed to be installed by engineers employed by the OEM. Computer hardware companies not only bundled their software, they also placed demands on the location of the hardware in a refrigerated space called a computer room. Most companies had their software on the books for 0 dollars, unable to claim it as an asset (this is similar to financing of popular music in those days). When Data General introduced the Data General Nova, a company called Digidyne wanted to use its RDOS operating system on its own hardware clone. Data General refused to license their software (which was hard to do, since it was on the books as a fee asset), and claimed their "bundling rights". The Supreme Court set a precedent called Digidyne v. Data General in 1995. The Supreme Court let a 9th circuit decision stand, and Data General was eventually forced into licensing the Operating System software because it was ruled that restricting the license to only DG hardware was an illegal *tring arrangement.*^[6] Soon after, IBM 'published' its DOS source for free, *licition needed*] and Microsoft was born. Unable to sustain the industry believed that anyone would profit from it other than IBM (through free publicity). Microsoft and Apple were abit to thus cash in on 'soft products. It is hard to imagine today that people once felt that software was worthless without a machine. There are many successful companies today that sell only software products, it hough there are still many companies into the complexity of designs and poor documentation, leading to patent trolls.

With open software specifications apple Inc. by sibility of software licensing, new opportunities arose for software tools that then became the de facto standard, such as DOS for operating systems, but also various proprietary word processing and spreadsheet programs. In a sixilar growth pattern, proprietary development methods became standard Software development methodology.

Figure 10. A Wikipedia article about "Computer software"

[edit]

| | η <mark>(</mark> Steve Jobs) | n <mark>C</mark> (Steve Jobs) | n <mark>D</mark> (Steve Jobs) | $\eta^{B}_{(\text{Steve Jobs})}$ |
|---|---|--|---|--|
| (Steve Jobs) | | | | |
| From Wikipedia, the free encyclopedia (Redirected from Steve jobs) | | | | |
| For the biography, see Steve Jobs (biography). | + | | | • |
| Steven Paul "Steve" Jobs (/d3obz/; February 24, 1955 – Octo was co-founder and previously served as chief executive of Pixar Disney. | ser 5, 2011) was an American business magnate and Animation Studios; he became a member of the boar | nventor. He was co-founder, chairman, and chief of directors of the Walt Disney Company in 2006 | executive officer of Apple Inc. Jobs following the acquisition of Pixar by | Steve Jobs |
| In the late 1970s, Jobs – along with Apple co-founder Steve Woz the Apple II series. In the early 1980s, Jobs was among the first year later, the Macintosh. After losing a power struggle with the to and business markets. In 1986, he acquired the computer graphics division of Lucasfilm majority shareholder at 50.1 percent until its acquisition by The V Directors. ^[9](10] Apple's 1996 buyout of NeXT brought Jobs back to spearheading the advent of the iPod, iPhone and iPad. ^[11] From 2 then elected chairman of Apple's board of directors. On October 5, 2011, around 3:00 p.m., Jobs died at his home in immediate cause of death, with "metastatic pancreas neuroendo Early life and education | iak, Mike Markkula and others – designed, develope o see the commercial potential of Xerox PARC's mou oard of directors in 1985, Jobs left Apple and founded Ltd, which was spun off as Pixar Animation Studios. ^[7] /alt Disney Company in 2006, ^[8] making Jobs Disney o the company he co-founded, and he served as its in 003, he fought a eight-year battle with cancer, ^[12] an Palo Alto, California, aged 56, six weeks after resigni rrine tumor" as the underlying cause. His occupation | d, and marketed one of the first commercially succure-driven graphical user interface, which led to the MeXT, a computer platform development company ⁷¹ He was credited in <i>Toy Story</i> (1995) as an execur's largest individual shareholder at seven percent a nterim CEO from 1997, then becoming permanent (d eventually resigned as CEO in August 2011, while an a CEO of Apple. A copy of his death certificate was listed as "entrepreneur" in the "high tech" bus | essful lines of personal computers, reation of the Apple Lisa and, one specializing in the higher-education twe producer. He remained CEO and d a member of Disney's Board of EO from 2000 onwards, e on his third medical leave. He was indicated respiratory arrest as the iness. ^[13] | Jobs holding a white IPhone 4 at Worldwide Developers Conference 2010 |
| Jobs was born in San Francisco and adopted at birth by Paul Job Clara later adopted a daughter, Patti. Paul Jobs, a machinist for accountant [^{14]} who tunkt him to nod hofere how mont to school | s and Clara Jobs (née Hagopian). They moved from S a company that made lasers, taught his son rudiment 1) Clara, back back page a payrall clark for Varian Acc | San Francisco to Mountain View, California when hi tary electronics and how to work with his hands. ^[1] | e was five years old. ^{[1][2]} Paul and His adoptive mother was an | Born Steven Paul Jobs February 24, 1955 ^[1] [2] |
| Asked in a 1995 interview what he wanted to pass on to his child | ren, Jobs replied, "Just to try to be as good a father t | o them as my father was to me. I think about that e | every day of my life." | October 5, 2011 (aged 56) ^[2] Palo Alto, California, U.S. |

Figure 11. A Wikipedia article about "Steve Jobs"

```
Given:
     D denotes the set of dictionaries (D_{_{U}},D_{_{A}},D_{_{L}})
     p denotes a phrase
     G is an inputted text consisting of multiple words
     S is a set of longest matching phrases such that \mathsf{S}\subset\mathsf{D}
     \oplus is the operation of joining two phrases using whitespace
Input:
     G = w_1 \oplus w_2 \oplus \square \oplus w_n
Algorithm:
     g \leftarrow split G into set of words
     p←Ø
     S \leftarrow \emptyset
     for i = 1 to n
           p←p⊕w_i
           if s is a match in D then
                 \mathtt{p}_{\texttt{saved}} \gets \mathtt{p}
                 i_{saved} \leftarrow i
                 continue
           else if p is a submatch in D then
                 continue
           else if p_{saved} \neq \emptyset then
S \leftarrow S \cup \{p_{saved}\}
           p←Ø
           p_{saved} \leftarrow \emptyset
           i \leftarrow i_{saved} + 1
```





Figure 13. nanobird Relevancy Engine Flowchart

The Great Lakes are in Danger July 22, 2011 : 5:10 PM

The effects of the climate crisis are now damaging the Great Lakes:

"Some of the Great Lakes' treasured national parks are showing ill effects of climate change that are likely to worsen in coming decades, from shoreline erosion to decline of certain wildlife and plant species, a former park system administrator said Wednesday,"

"Without changes in public policies and personal habits that pump greenhouse gases into the atmosphere, the parks could lose qualities that attract visitors and support unique ecosystems. Stephen Saunders, former deputy assistant secretary of the Interior Department, said in a report released by two advocacy groups."

Source: AP

Figure 14. An example of natural language data



Figure 15. Partial fingerprint of the phrase "Atmosphere of Earth"



Figure 16. Partial fingerprint of the phrase "Climate change"



Figure 17. Partial fingerprint of the phrase "Ecosystem"



Figure 18. Partial fingerprint of the phrase "Global warming"



Figure 19. Partial fingerprint of the phrase "Greenhouse gas"



Figure 20. An example of a nanobird Context Analyzer Graph

@DrOz Interests*

Food Health Eating Research Nutrition Physical exercise Websites Physical fitness

@NYTimeskrugman Interests*

| Unemployment |
|---------------------|
| Economy |
| Keynesian economics |
| Inflation |
| Monetary policy |
| Suffering |
| Interest rate |
| Macroeconomics |
| Fiscal policy |
| Economics |
| Middle East |
| Affect psychology |
| Affective science |

@geostella Interests*

Sun Solar energy Energy Renewable energy Manufacturing Technology Solar power Business

| @AccelGrowth Interests* | @billgates Interests* | @MikeBloomberg Interests* |
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| @ACCEIGROWTN Interests * Business Investment Technology Venture capital Companies | (@billgates Interests* Technology Vaccination Education Investment Funding Teacher World Scientific method | @MIKeBIoomberg Interests* New York City Michael Bloomberg Mayor of New York City Charitable organization New York Bloomberg L.P. Philanthropy Manhattan |
| | Money School Science Poverty | Foundation non-profit Health Economy |

Figure 21. Example showing the interest of some Twitter users after being processed by the twitter application using nRE