

Supplemental Information for Summarizing User-generated Textual Content: Motivation and Methods for Fairness in Algorithmic Summaries Proceedings of ACM CSCW 2019

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1 FairSumm: Proposed In-processing Algorithm for Fair Summarization

This section describes FairSumm, our proposed in-processing algorithm for fair summarization, in more detail. This algorithm treats summarization as an optimization problem of a submodular, monotone objective function, where the fairness requirements are applied as constraints. In this section, we first establish the theoretical premise of our algorithm, and then describe our algorithm. The symbols used in this section are given in Table 1.

1.1 Submodularity and Monotonicity

Definitions: Let $V = \{v_1, v_2, \dots, v_n\}$ be the set of elements to be summarized, where each v_i represents a textual unit (e.g., a tweet). We define a function $\mathcal{F} : 2^V \rightarrow \mathbb{R}$ (the set of real numbers) that assigns a real value to a subset (say, S) of V . Our goal is to find $S (\subseteq V)$ such that $|S| \leq k$, where $k \in \mathbb{R}$ is the desired length of the summary (specified as an input), and for which \mathcal{F} is maximized (i.e. $S = \operatorname{argmax}_{B \subseteq V} \mathcal{F}(B)$). So, from a set of textual units V , we look to find a summary S that maximizes an objective function \mathcal{F} .

Definition 1 (Discrete derivative) [1]: For $e \in V$ and a function $f : 2^V \rightarrow \mathbb{R}$, let $\Delta(e|S) = f(S \cup \{e\}) - f(S)$ be the *discrete derivative* of f at S with respect to e .

Definition 2 (Submodularity): a function f is *submodular* if for every $A \subseteq B \subseteq V$ and $e \in V \setminus B$ (i.e. $e \in V$ and $e \notin B$),

$$\Delta(e|A) \geq \Delta(e|B) \quad (1)$$

This property is popularly called the *property of diminishing returns*.

Definition 3 (Monotonicity): The function f is *monotone* (or *monotone nondecreasing*) if for every $A \subseteq B \subseteq V$, $f(A) \leq f(B)$

Properties: We now discuss some of the important properties of monotone submodular functions which we will exploit in our problem formulation.

Property 1 (The class of submodular functions is closed under non-negative linear combinations): Let f_1, f_2, \dots, f_n defined by

$f_i : 2^V \rightarrow \mathbb{R}$ ($i = 1, 2, \dots, n$) be submodular functions and $\lambda_1, \lambda_2, \dots, \lambda_n$ be non-negative real numbers. Then $\sum_{i=1}^n \lambda_i f_i$ is also submodular.

Proof: This is a well-known property of submodular functions (e.g., see [2]), hence the proof is omitted.

Property 2 (The class of monotone functions is closed under non-negative linear combinations): Let f_1, f_2, \dots, f_n defined by

$f_i : 2^V \rightarrow \mathbb{R}$ ($i = 1, 2, \dots, n$) be monotone functions and $\lambda_1, \lambda_2, \dots, \lambda_n$ be non-negative real numbers. Then $\sum_{i=1}^n \lambda_i f_i$ is also monotone.

Proof: Let $A_1 \subseteq A_2 \subseteq V$. Then, since each f_i is a monotone, $f_i(A_1) \leq f_i(A_2)$. Let $F = \sum_{i=1}^n \lambda_i f_i$.

Symbols	Meanings
V	Set of textual units to be summarized
N	$ V $, number of textual units to be summarized
t	Number of classes to which the textual units in V belong (e.g., $t = 2$ for MeToo dataset, $t = 3$ for US-Election)
Z_1, Z_2, \dots, Z_t	The t classes of the textual units
S	Summary conforming to fairness notions ($S \subseteq V$)
k	Desired length of summary, $ S $
$c_i, i = 1 \dots t$	Minimum number of textual units from class Z_i to be included in S (to satisfy a given fairness notion)
\mathcal{F}	Objective function (overall goodness measure of S)
\mathcal{L}	Coverage function (goodness measure of S)
\mathcal{R}	Diversity reward function (goodness measure of S)
$sim(i, j)$	Similarity score between two textual units $i, j \in V$
\mathcal{M}	A (partition) matroid
\mathcal{I}	Set of partitions of matroid \mathcal{M}
G	The optimized fair summary produced by Algorithm 1

Table 1: The main symbols used in Section 1.

Case I: Let $\lambda_i = 0$, for all $i = 1, 2, \dots, n$. Then, $F = 0$ and is a constant (non-decreasing) function.

Case II: Let $\lambda_i > 0$, for all $i = 1, 2, \dots, n$. Then we can write

$$\begin{aligned}
A_1 \subseteq A_2 &\Rightarrow f_i(A_1) \leq f_i(A_2), \forall i \Rightarrow \sum_i^n f_i(A_1) \leq \sum_i^n f_i(A_2) \\
&\Rightarrow \sum_i^n \lambda_i f_i(A_1) \leq \sum_i^n \lambda_i f_i(A_2) \quad [\because \lambda_i > 0, \forall i] \\
&\Rightarrow F(A_1) \leq F(A_2).
\end{aligned}$$

Case III: Let only some m ($m > 0$ and $m < n$) λ_i s > 0 . Let, without any loss of generality, such λ_i s be $\lambda_1, \lambda_2, \dots, \lambda_m$. Then we have

$$\begin{aligned}
A_1 \subseteq A_2 &\Rightarrow f_i(A_1) \leq f_i(A_2), \forall i \Rightarrow \sum_i^m f_i(A_1) \leq \sum_i^m f_i(A_2) \\
&\Rightarrow \sum_i^m \lambda_i f_i(A_1) \leq \sum_i^m \lambda_i f_i(A_2) \quad [\because \lambda_i > 0, \text{ for } i = 1, 2, \dots, m] \\
&\Rightarrow \sum_i^n \lambda_i f_i(A_1) \leq \sum_i^n \lambda_i f_i(A_2) \quad [\because \lambda_i = 0, \text{ for } i = m + 1, m + 2, \dots, n] \\
&\Rightarrow F(A_1) \leq F(A_2)
\end{aligned}$$

This completes the proof.

Property 3 (The class of monotone submodular functions is closed under non-negative linear combinations): Let f_1, f_2, \dots, f_n defined by $f_i : 2^V \rightarrow \mathbb{R}$ ($i = 1, 2, \dots, n$) be monotone submodular functions and $\lambda_1, \lambda_2, \dots, \lambda_n$ be non-negative real numbers. Then $\sum_i \lambda_i f_i$ is also monotone submodular.

Proof: This follows trivially from Properties 1 and 2.

Property 4: Given functions $F : 2^V \rightarrow \mathbb{R}$ and $f : \mathbb{R} \rightarrow \mathbb{R}$, the composition $F' = f \circ F : 2^V \rightarrow \mathbb{R}$ (i.e., $F'(S) = f(F(S))$) is nondecreasing sub-modular, if f is non-decreasing concave and F is nondecreasing submodular.

Proof: This is also a well-known property of submodular functions (e.g., see [2]), hence the proof is omitted.

1.2 Formulation of the objective function for summarization

We now look for an objective function for the task of extractive summarization. Following the formulation by Lin *et al.* [2], we use monotone submodular functions to construct the objective function. We consider the following two

aspects of an extractive text summarization algorithm:

Coverage: Coverage refers to amount of information covered in the summary S , measured by a function, say, \mathcal{L} . The generic form of \mathcal{L} can be

$$\mathcal{L}(S) = \sum_{i \in S, j \in V} sim_{i,j} \quad (2)$$

where $sim_{i,j}$ denotes the similarity between two textual units (tweets, sentences, etc.) $i \in V$ and $j \in V$. Thus, $\mathcal{L}(S)$ measures the overall similarity of the textual units included in the summary S with all the textual units in the input collection V .

Note that \mathcal{L} is monotone submodular. \mathcal{L} is monotonic since coverage increases by the addition of a new sentence in the summary. At the same time, \mathcal{L} is submodular since the increase in \mathcal{L} would be more when a sentence is added to a shorter summary, than when a sentence is added to a longer summary. There can be several forms of \mathcal{L} depending on how $sim_{i,j}$ is measured, which we will discuss later in this paper.

Diversity reward: The purpose of this aspect is to avoid redundancy and reward diverse information in the summary. Let the associated function be denoted as \mathcal{R} . A generic formulation of \mathcal{R} is

$$\mathcal{R}(S) = \sum_{i=1}^K \sqrt{\sum_{j \in P_i \cap S} r_j} \quad (3)$$

where P_1, P_2, \dots, P_K comprise a partition of V such that $\cup_i P_i = V$ and $P_i \cap P_j = \emptyset$ for all $i \neq j$; r_j is a suitable monotone submodular function that estimates the importance of adding the textual unit j to the summary. The partitioning P_1, P_2, \dots, P_K can be achieved by clustering the set V using any clustering algorithm (e.g., K -means), based on the similarity of items as measured by $sim(i, j)$.

$\mathcal{R}(S)$ rewards diversity since there is more benefit in selecting a textual unit from a partition (cluster) that does not yet have any of its elements included in the summary. As soon as any one element from a cluster P_i is included in the summary, the other elements in P_i start having diminishing gains, due to the square root function.

The function r_j is a ‘singleton reward function’ since it estimates the reward of adding the singleton element $j \in V$ to the summary S . One possible way to define this function is:

$$r_j = \frac{1}{N} \sum_i sim(i, j) \quad (4)$$

which measures the average similarity of j to the other textual units in V . Note that $\mathcal{R}(S)$ is monotone submodular by Property (4), since square root is a non-decreasing concave function. This formulation will remain monotone submodular if any other non-decreasing concave function is used instead of square root.

While constructing a summary, both coverage and diversity are important. Only maximizing coverage may lead to lack of diversity in the resulting summary and vice versa. So, we define our objective function for summarization as follows:

$$\mathcal{F} = \lambda_1 \mathcal{L} + \lambda_2 \mathcal{R} \quad (5)$$

where $\lambda_1, \lambda_2 \geq 0$ are the weights given to coverage and diversity respectively. Note that, by Property (3), \mathcal{F} is monotone submodular.

Our proposed fairness-preserving summarization algorithm will maximize \mathcal{F} in keeping with some fairness constraints. We now discuss this step.

1.3 Submodular Maximization using Partition Matroids

For fairness-preserving summarization, we essentially need to optimize the submodular function \mathcal{F} while ensuring that the summary includes at least a certain number of textual units from each class present in the input data. This problem can be formulated using the concept of partition matroids, as described below.

Definitions: We start with some definitions that are necessary to formulate the constrained optimization problem.

Definition 4 (Matroid): A matroid is a pair $\mathcal{M} = (\mathcal{Z}, \mathcal{I})$, defined over a finite set \mathcal{Z} (called the ground set) and a family of sets \mathcal{I} (called the independent sets), that satisfies the three properties:

1. \emptyset (empty set) $\in \mathcal{I}$.

2. If $Y \in \mathcal{I}$ and $X \subseteq Y$, then $X \in \mathcal{I}$.
3. If $X \in \mathcal{I}$, $Y \in \mathcal{I}$ and $|Y| > |X|$, then there exists $e \in Y \setminus X$ such that $X \cup \{e\} \in \mathcal{I}$.

Definition 5 (Partition Matroids): Partition matroids refer to a special type of matroids where the ground set \mathcal{Z} is partitioned into disjoint subsets $\mathcal{Z}_1, \mathcal{Z}_2, \dots, \mathcal{Z}_s$ for some s and $\mathcal{I} = \{S \mid S \subseteq \mathcal{Z} \text{ and } |S \cap \mathcal{Z}_i| \leq c_i, \text{ for all } i = 1, 2, \dots, s\}$ for some given parameters c_1, c_2, \dots, c_s . Thus, S is a subset of \mathcal{Z} that contains at most c_i items from the partition \mathcal{Z}_i (for all i), and \mathcal{I} is the family of all such subsets.

Formulation of the constrained maximization problem: Consider that we have a set of control variables z_j (e.g., gender, political leaning), each of which takes t_j distinct values (e.g., male and female, democrat and republican). Each item in \mathcal{Z} has a particular value for each z_j .

For each control variable z_j , we can partition \mathcal{Z} into t_j disjoint subsets $\mathcal{Z}_{j1}, \mathcal{Z}_{j2}, \dots, \mathcal{Z}_{jt_j}$, each corresponding to a particular value of this control variable. We now define a partition matroid $\mathcal{M}_j = (\mathcal{Z}, \mathcal{I}_j)$ such that

$$\mathcal{I}_j = \{S \mid S \subseteq \mathcal{Z} \text{ and } |S \cap \mathcal{Z}_{ji}| \leq c_j, \text{ for all } i = 1, 2, \dots, t_j\}$$

for some given parameters c_1, c_2, \dots, c_{t_j} .

Now, for a given submodular objective function f , a submodular optimization under the partition matroid constraints with P control variables can be designed as follows:

$$\begin{aligned} & \text{Maximize}_{S \subseteq \mathcal{Z}} f(S) \\ & \text{subject to } S \in \bigcap_{j=1}^P \mathcal{I}_j. \end{aligned} \tag{6}$$

A prior work by Du *et al.* [3] has established that this submodular optimization problem under the matroid constraints can be solved efficiently with provable guarantees (see [3] for details).

1.4 Proposed summarization scheme

In the context of the summarization problem, the ground set is $V (= \mathcal{Z})$, the set of all textual units (sentences/tweets) which we look to summarize. The control variables (stated in Section 1.3) are analogous to the sensitive attributes with respect to which fairness is to be ensured. In this work, we consider only one sensitive attribute for a particular dataset (the gender of a user for the Claritin dataset, political leaning of a tweet for the US-Election dataset, and the media source for the DUC06 dataset). Let the corresponding control variable be z , and let z take t distinct values (e.g., $t = 2$ for the Claritin dataset, and $t = 3$ for the US-Election dataset). Note that, as described in Section 1.3, the formulation can be extended to multiple sensitive attributes (control variables) as well.

Each textual unit in V is associated with a class, i.e., a particular value of the control variable z (e.g., is posted either by a male or a female). Let Z_1, Z_2, \dots, Z_t ($Z_i \subseteq V$, for all i) be the disjoint subsets of the textual units from the t classes, each associated with a distinct value of z . We now define a partition matroid $\mathcal{M} = (V, \mathcal{I})$ in which V is partitioned into disjoint subsets Z_1, Z_2, \dots, Z_t and

$$\mathcal{I} = \{S \mid S \subseteq V \text{ and } |S \cap Z_i| \leq c_i, i = 1, 2, \dots, t\}$$

for some given parameters c_1, c_2, \dots, c_t . In other words, \mathcal{I} will contain all the sets S containing at most c_i sentences from Z_i , $i = 1, 2, \dots, t$.

Outside the purview of the matroid constraints, we maintain the restriction that c_i 's are chosen such that

- (1) $\sum_{i=1}^t c_i = k$ (the desired length of the summary S), and
- (2) a desired fairness criterion is maintained in S . For instance, if equal representation of all classes in the summary is desired, then $c_i = \frac{k}{t}$ for all i .

We now express our fairness-constrained summarization problem as follows:

$$\begin{aligned} & \text{Maximize}_{S \subseteq V} \mathcal{F}(S) \\ & \text{subject to } S \in \mathcal{I}. \end{aligned} \tag{7}$$

Algorithm 1 : FairSumm (for fair summarization)

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1: Set  $d = \max_{z \in V} \mathcal{F}(\{z\})$ .
2: Set  $w_t = \frac{d}{(1+\delta)^t}$  for  $t = 0, \dots, l$  where  $l = \operatorname{argmin}_i [w_i \leq \frac{\delta d}{N}]$ , and  $w_{l+1} = 0$ .
3: Set  $G = \emptyset$ 
4: for  $t = 0, 1, \dots, l, l + 1$  do
5:   for each  $z \in V$  and  $G \cup \{z\} \in I$  do
6:     if  $\mathcal{F}(G \cup \{z\}) - \mathcal{F}(G) \geq w_t$  then
7:       Set  $G \leftarrow G \cup \{z\}$ 
8:     end if
9:   end for
10: end for
11: Output  $G$ 
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where the objective function $\mathcal{F}(S)$ is as stated in Equation 5.

The suitable algorithm to solve this constrained submodular optimization problem, proposed by Du et al. [3], is presented as Algorithm 1. The G produced by Algorithm 1 is the solution of Equation 7. This algorithm is an efficient alternative to the greedy solution which has a time complexity of $\mathcal{O}(kN)$ where $N = |V|$ and $k = |S|$. On the other hand, it can be shown that the time complexity of Du et al. [3] is $\mathcal{O}(\min\{|G|N, \frac{N}{\delta} \log \frac{N}{\delta}\})$, where δ is a factor (to be explained shortly). The reason for this efficiency is the fact that this algorithm does *not* perform exhaustive evaluation of all the possible submodular functions evolving in the intermediate steps of the algorithm. Instead, it keeps on decreasing the threshold w_t by a dividing factor $(1 + \delta)$, which skips the evaluation of many submodular functions and sets the threshold to zero when it is small enough. It selects elements z from the ground set (in our case, V) only at each threshold value to evaluate the marginal gain ($\mathcal{F}(G \cup \{z\}) - \mathcal{F}(G)$) without violating any constraints.

Note that, the theoretical guarantee of Algorithm 1 depends upon the number of partition matroids (P), i.e., the number of control variables, and the curvature (c_f) of \mathcal{F} given by

$$c_f = \max_{j \in V, \mathcal{F}(j) > 0} \frac{\mathcal{F}(j) - \mathcal{F}(j|V \setminus \{j\})}{\mathcal{F}(j)}$$

The approximation ratio is $\frac{1}{P+c_f}$ (see [3] for details); in our setting, the number of partition matroids P is 1.

Algorithm for fair summarization: Algorithm 1 presents the algorithm to solve this constrained submodular optimization problem, based on the algorithm developed by Du et al. [3]. The G produced by Algorithm 1 is the solution of Equation 7. We now briefly describe the steps of Algorithm 1.

In Step 1, the maximum value of the objective function \mathcal{F} that can be achieved for a text unit z ($\in V$) is calculated and stored in d . The purpose of this step is to compute the maximum value of \mathcal{F} for a single text unit z and set a selection threshold (to be described shortly) with respect to this value. This step will help in the subsequent selection of textual units for the creation of the summary to be stored in G . w_t (defined in Step 2) is such a threshold at the t^{th} time step. w_t is updated (decreased by division with a factor $1 + \delta$) for $t = 0, 1, \dots, l$. l is the minimum value of i for which $w_i \leq \frac{\delta d}{N}$ holds (see Du et al. [3] for details) and w_{l+1} is set to zero. In Step 3, G (the set that will contain the summary) is initialized as an empty set. Note that G is supposed to be an independent set according to the definition of matroid given earlier in this section. By the condition (1) in the definition of matroids (stated earlier in this section), an empty set is independent. Step (4) iterates through the different values of t . Step (5) tests, for each z (text element) $\in V$, if G remains an independent set by the inclusion of z . Only those z 's are chosen in this step whose inclusion expands G (already an independent set) to another independent set. Step (6) selects a z (permitted by Step (5)) for inclusion in G if $\mathcal{F}(G \cup \{z\}) - \mathcal{F}(G) \geq w_t$. This z is added to G in Step (7). That is, z is added to G if the increment of \mathcal{F} by the addition of z is not less than the threshold w_t . For $t = 0$, $w_t = d$, that is, the maximum value of \mathcal{F} for any z ($\in V$). This means, the z which maximizes \mathcal{F} is added to G . Note that, there can be multiple z 's for which \mathcal{F} is maximized. In that case, the tie is broken arbitrarily. The remaining z 's may or may not be added to G based on the threshold value.

Another important point to note is that, our chosen \mathcal{F} (see equation (5)) is designed to maximize both coverage and diversity. So, even if multiple z 's satisfy Step (5), they may not be added to G in Step (7) if they contain redundant information. The value of w_t is relaxed for the subsequent values of t to allow text elements z producing relatively lower increments of \mathcal{F} to be considered for possible inclusion in G . $w_{l+1} = 0$ indicates that for the final value of t at least one text unit z which does not decrement \mathcal{F} is added to G . This ensures that the coverage of the summary

produced is not compromised while preserving diversity. This process (Steps (5) to (7)) is repeated for $t = 0, 1, \dots, l, l + 1$ resulting in the final output G .

The reason for the efficiency of Algorithm 1 is the fact that this algorithm does *not* perform exhaustive evaluation of all the possible submodular functions evolving in the intermediate steps of the algorithm. The reduction in the number of steps in the algorithm is achieved mainly by decreasing w_t geometrically by a factor of $1 + \delta$. In addition, multiple elements z can be added to G for a single threshold which also expedites the culmination of the algorithm.

2 Sample Summaries of the Datasets

We give some examples of summaries generated by the different summarization algorithms discussed in the paper, on two datasets – (i) MeToo dataset, and (ii) US Election dataset. The datasets are described in detail in the original paper. All summaries shown here are of length $k = 20$ tweets.

2.1 Summaries of MeToo Dataset

Here are few summaries produced with different fairness constraints of the MeToo Dataset.

Summary produced by Sumbasic algorithm: (14 tweets by Females & 6 tweets by Males)

- Abusers aren't Victims, Opportunists aren't Crusaders. Slut shamers shudn't talk about Slut Shaming & cowards shudn't pretend to be warriors. This is what Sonam Mahajan who I once considered a friend did to me. Telling this now seeing her blatant bigotry & hypocrisy around #MeToo
- 1. All the rapes and #MeToo #MeTooIndia allegations give raise to one question. 'when will it stop?' But the questions must be "when did it start?" And "How long has it taken for us to standup against it?"
- I need influencers to help me get the word out. I need 1000s if people to follow me & RT. I need a Dateline long format interview & to talk to Oprah. I need funding and support. I am Alex Jones ex-wife & I am NOT the underdog. I am you. I am America, #metoo & can change this.
- Apparently I'm only scared because of #metoo even though the movement didn't exist at the time
- Good to see India's top uni take a no-nonsense approach to sexual harassment in #academia #Metoo: IISc shows door to top professor on charges of sexual harassment
- The first story on Talk, Dammit was mine. The first person I opened up to about having been molested as a child was Faizan. Please dont believe this attention seeking bully of a woman, Faizan has been there for me and countless others even before there was a #metoo movement.
- Also - the jokes. The jokes. If I now shake hands with you, will you yell #MeToo? It is that funny, is it? Women and so many men finally found the strength to share the stories of sexual misconduct and assault and some men need to joke about it.
- And it would be because of the actions of a few girls like #MeghaSharma who abuse #metoo , one day it will probably have its own #metoo movement as a mark of protest.
- @SmartKehan @MIKENY78 @MailOnline #metoo ignores evidence and thats not right because a Man is Human and he has the rights as Woman but they doesnt understand that . #Feministsaremonster
- Allowing a clear serial sexual predator to run one of your labels is a bad look, @AtlanticRecords. You need to drop @adam22 now. #MeToo #BelieveWomen
- My model friend @kawaljitanand has taken the initiative to come forward and speak about his #Metoo experience in the fashion industry. LEAD THE WAY KAWAL. Proud of you. Hope more men come forward to expose their experience with the predators around. #KawaljitAnand #MeTooIndia
- It is becoming more commonplace for schools to offer support groups for boys. Here they feel safe to discuss their emotions and learn to navigate their relationship with girls in the #metoo movement #UBSW510 Boy Talk: Breaking Masculine Stereotypes
- #Metoo dies a little more everyday. Bryan Singer is back at work. Woody Allen is getting support. James Gunn is back at work. Harvey Weinstein is pretty much on the verge of being cleared of any charges. CeeLo Green is back on the voice. America really doesn't care about rape.
- For ladies in #Gambia. Im working on a series of survivor stories within the context of #MeToo, told exactly as the survivors would choose. If youre a survivor or know someone who is comfortable with it, and would want to share their story, please DM me.

- @danprimack @UCLA ask: in the light of #metoo movements and Harvey Weinstains, how do they feel about using money and lawyers to silence victims under NDAs instead of letting justice run its course, how did they address the problem in their organizations?
- @HillaryClinton Trump is right; a vote for Republicans on November 6th is a vote for him. Its a vote against women, a vote against freedom of speech, a vote for racism, a vote for hate crimes, a vote for acceptance of his lies. #MeToo #JamalKhashoggi #MAGABomber #PittsburghSynagogueShooting
- If the fear about #MeToo is false accusations against men, then the GOP SHOULDN'T BE OFFERING \$\$\$ TO WOMEN TO MAKE FALSE ALLEGATIONS AGAINST ROBERT MUELLER!!! #AreWeGreatEnoughYet
- Still, better than the sports masseur who said I lit him up like a Christmas tree, stroked the side of my breast, put his penis in my upturned palm & said hed love to put cameras all over my house so he could watch me all day ...I just cant even... #metoo #sexualharassment
- @annavetticad @TheQuint Salmans is an issue of domestic violence. Not to be conflated with #MeToo. Diluting the def of #MeToo will dampen its impact. Its def should be restricted to people in power sexually exploiting the weak. Not domestic violence or failed relationships
- It takes immense courage to this young woman ananya to express and write her story! Really the time's up!! This young actress faced lots of mental, emotional & physical abuse from another woman!! #MeToo please read her story in the FB link with this tweet.

Summary produced by applying Proportional Representation on the Sumbasic algorithm (11 tweets by Females & 9 tweets by Males) [Algorithm II]

- I need influencers to help me get the word out I need 1000s if people to follow me & RT I need a Dateline long format interview & to talk to Oprah I need funding and support I am Alex Jones ex-wife & I am NOT the underdog I am you I am America, #metoo & can change this.
- @WomenInFilm #womeninfilm #BelieveSurvivors #timesup #metoo #ChristineBlaseyFord #MKUTRA #Hypocrites #Hypocrisy #BoycottHollywood The #Truth is, you #Women 'Walked Out' of having any #Common-Sense You're all 'Puppets of #PedoWood' #WalkAway.
- Apparently I'm only scared because of #metoo even though the movement didn't exist at the time.
- 1 All the rapes and #MeToo #MeTooIndia allegations give raise to one question 'when will it stop" But the questions must be "when did it start" And "How long has it taken for us to standup against it".
- #METOO MEN WHO SEXUALLY HARASS WOMEN DONT SEE IT AS SEXUAL HARASSMENT #WOMENTOO DOES THE SAME.
- Today I spoke to a victim of #FalseAllegations we stay in contact and touch base regularly He's still angry at he's treatment by the so called justice system He spent just over 3 months in prison till he's acquittal As a pensioner he spent over \$100k on he's defense #MeToo.
- In the current climate of #MeToo if someone did that to you at your place of work would you just let it go Or should it be considered sexual assault.
- @skhndh Another thing you are not alone in Its been mentally consuming for me It was was one of your tweets shared but @ghaatidancer that pushed me through my silence and made me share my story We are all in this together and its high time So be proud #MeToo.
- And it would be because of the actions of a few girls like #MeghaSharma who abuse #metoo , one day it will probably have its own #metoo movement as a mark of protest.
- The left has hyjacked the #metoo movement The left does not believe in innocent until proven guilty The left does not believe in America first instead they would rather put every country ahead of the United States.
- In many organizations, content is also raising its #MeToo voice for the way it is treated there #contentstrategy.
- All the gentlemen who have been urging me via direct messages to talk about my personal #MeToo experience(s) - please look for this soft porn gratification from the low cost data services now available Or you could make a quick trip to Bangkok (without bhabhiji) #NoJudgement.
- @SmartKehan @MIKENY78 @MailOnline #metoo ignores evidence and thats not right because a Man is Human and he has the rights as Woman but they doesnt understand that #Feministsaremonster.
- Any feminist lawyers out there want to join forces and learn cutting edge defamation law so we can protect people who speak out in the #metoo movement Im in Vancouver and want to join a collective to level the playing field.
- @Chinmayi Can you take back the shame and humiliation this guy faced bcoz of what you have done to him

He should seriously file defamation case against you #MeTooControversy #metoo.

- I hope the #metoo sexual assault allegations in India tear down every perpetrator of sexual violence in Bollywood and beyond I hope the industry crumbles from within and rebuilds something new.
- Party coming to SM disclosing his proof of innocence He is having access to those ministers who r appointed as GoM in #MeToo campaign but he preferred to come to SM bcoz he knows #Vote matters even they would have not listened to #GenderAppeasement Now pl think about #NOTA4Men.
- @rosemcgowan You are the founder of #metoo and as such I feel that you should stand for anyone being abused Johnny Depp made the mistake of marrying Amber Heard but shes trashed his name when shes really the abuser She should be accountable and is not Here are the court.
- A year ago today I thought my world was falling apart I woke up to find out that the hashtag #metoo had gone viral and I didn't see any of the work I laid out over the previous decade attached to it I thought for sure I would be erased from a thing I worked so hard to build.
- Excellent news Should have happened right away but good that it happened now Thanks to @TataCompanies for doing the right thing Meanwhile Suhel Seth continues to hide in whatever hole he's crawled into #MeToo.

Summary produced by applying Equal Representation on the Sumbasic algorithm (10 tweets by Females & 10 tweets by Males) [Algorithm II]

- I need influencers to help me get the word out I need 1000s if people to follow me & RT I need a Dateline long format interview & to talk to Oprah I need funding and support I am Alex Jones ex-wife & I am NOT the underdog I am you I am America, #metoo & can change this.
- @WomenInFilm #womeninfilm #BelieveSurvivors #timesup #metoo #ChristineBlaseyFord #MKUTRA #Hypocrites #Hypocrisy #BoycottHollywood The #Truth is, you #Women 'Walked Out' of having any #Common-Sense You're all 'Puppets of #PedoWood' #WalkAway
- Apparently I'm only scared because of #metoo even though the movement didn't exist at the time.
- I All the rapes and #MeToo #MeTooIndia allegations give raise to one question 'when will it stop" But the questions must be "when did it start" And "How long has it taken for us to standup against it".
- #METOO MEN WHO SEXUALLY HARASS WOMEN DONT SEE IT AS SEXUAL HARASSMENT #WOMENTOO DOES THE SAME.
- Today I spoke to a victim of #FalseAllegations we stay in contact and touch base regularly He's still angry at he's treatment by the so called justice system He spent just over 3 months in prison till he's acquittal As a pensioner he spent over \$100k on he's defense #MeToo.
- @skhndh Another thing you are not alone in Its been mentally consuming for me It was was one of your tweets shared but @ghaatidancer that pushed me through my silence and made me share my story We are all in this together and its high time So be proud #MeToo.
- The #MeToo movement is officially dead. The left only cares about women's sexual assault allegations when it is against a rival political party. They NEVER cared about the claims of the victims! #ThesePeopleAreSick #HypocriticalLeft #VoteDemsOut #PedoWood #RapeIsntAJoke
- In the current climate of #MeToo if someone did that to you at your place of work would you just let it go Or should it be considered sexual assault
- All the gentlemen who have been urging me via direct messages to talk about my personal #MeToo experience(s) - please look for this soft porn gratification from the low cost data services now available Or you could make a quick trip to Bangkok (without bhabhiji) #NoJudgement
- The left has hyjacked the #metoo movement The left does not believe in innocent until proven guilty The left does not believe in America first instead they would rather put every country ahead of the United States.
- Any feminist lawyers out there want to join forces and learn cutting edge defamation law so we can protect people who speak out in the #metoo movement Im in Vancouver and want to join a collective to level the playing field.
- In many organizations, content is also raising its #MeToo voice for the way it is treated there #contentstrategy.
- I hope the #metoo sexual assault allegations in India tear down every perpetrator of sexual violence in Bollywood and beyond I hope the industry crumbles from within and rebuilds something new.
- @SmartKehan @MIKENY78 @MailOnline #metoo ignores evidence and thats not right because a Man is Human and he has the rights as Woman but they doesnt understand that #Feministsaremonster.
- @rosemcgowan You are the founder of #metoo and as such I feel that you should stand for anyone being abused

Johnny Depp made the mistake of marrying Amber Heard but she's trashed his name when she's really the abuser. She should be accountable and is not. Here are the courts.

- A year ago today I thought my world was falling apart. I woke up to find out that the hashtag #metoo had gone viral and I didn't see any of the work I laid out over the previous decade attached to it. I thought for sure I would be erased from a thing I worked so hard to build.
- @Chinmayi Can you take back the shame and humiliation this guy faced because of what you have done to him? He should seriously file a defamation case against you #MeTooControversy #metoo
- Excellent news. Should have happened right away but good that it happened now. Thanks to @TataCompanies for doing the right thing. Meanwhile, Suhel Seth continues to hide in whatever hole he's crawled into #MeToo.
- Party coming to SM disclosing his proof of innocence. He is having access to those ministers who were appointed as GoM in #MeToo campaign but he preferred to come to SM because he knows #Vote matters even though they would have not listened to #GenderAppeasement. Now please think about #NOTA4Men.

Summary produced by applying Proportional Representation on proposed FairSumm Algorithm (11 tweets by Females & 9 tweets by Males) [Algorithm I]

- I need influencers to help me get the word out. I need 1000s of people to follow me & RT. I need a Dateline long format interview & to talk to Oprah. I need funding and support. I am Alex Jones ex-wife & I am NOT the underdog. I am you. I am America, #metoo & can change this.
- IMPORTANT : My DMs are open. Let's hear #HimToo #MenToo and the #MeToo stories of Men. Tell me about cases where you as a man or a man you know has been abused, sexually assaulted, harassed, intimidated, falsely accused and not even heard let alone believed. REACH OUT & RT.
- It is not just Suhel Seth's silence. It's also the unacceptable silence of many in media who knew him professionally and socially. I did too like many others. I spoke up but I can count on one hand those of us who have demanded accountability from him #MeToo : Where are others?
- @SenatorCollins Too bad you don't really believe in the power of truth. How can you live with yourself, knowingly voting for an alcoholic abuser of women. Next time I am sexually assaulted I will first ask if anyone would like to witness for prosperity's sake #metoo screw you.
- I for one believe all women which is why I will believe this Mueller accuser until it is proven she is or isn't lying. Sure is odd. All the media is trying to get out in front of this before we even have the accuser's name though for those noting.. #Metoo
- A year ago today I thought my world was falling apart. I woke up to find out that the hashtag #metoo had gone viral and I didn't see any of the work I laid out over the previous decade attached to it. I thought for sure I would be erased from a thing I worked so hard to build.
- I admire the courage of @priyaramani & all the victims who spoke out against sexual harassment & abuse. @mjakbar's resignation is a moral victory for everyone. The defamation case can't change that. The #MeToo movement needs support across party lines.
- @MIKENY78 @SmartKehan @MailOnline That to they lied and now they want to lynch every Man on Earth . The Whole #metoo is Stupid . Its Dangerous to believe every woman . No Man is safe anymore when someone doesn't like you they cry #metoo . It can happen to everyone
- @varshapillai @womensweb Are women that weak that they need a hashtag to speak out ? I'm sure women are strong enough to fight without social media. At least women around me are. #metoo needs to be stopped because it does really promote more fake cases. Instead fight the real one bravely and we support u.
- As I cry and succumb to mental exhaustion because of #MeToo060 , I remember the friendships women forged and solidarity we showered upon each other. Each one of you who has helped, supported, fought the war, been there relentlessly - I will never forget. Thank you. I love you.
- She has no cellphone and doesn't use hashtags. "What is misleading is that people say #MeToo is an urban elite thing that must reach the poor. It's actually the other way around." "They Deserve Justice": Mother Of India's #MeToo Speaks Out
- Excellent news. Should have happened right away but good that it happened now. Thanks to @TataCompanies for doing the right thing. Meanwhile, Suhel Seth continues to hide in whatever hole he's crawled into #MeToo.
- I'm so fucking stupid everyone always says don't get in a stranger's car. I'm fucking smarter than this. I hate this world you can never trust anyone. I'm fine, he just tried to hold my hand, put his hand on my leg. I got home safely but still... he was 60 and I'm 17 #metoo

- These wounds come from a culture infection; we know where it began. It's effects has lasted for generations and the time to cleanse it all out is now. This isn't our shame to hold any longer. This was never ours to begin with. #IndigenousMeToo #Indigenous #MeToo
- If a guy says he's nervous about #MeToo, just remind him that we come down pretty hard on murderers too, and ask him why that doesn't make him nervous. If he says, "Because I haven't murdered anyone," then you've learned something new about your friend.
- I had to cancel a follow up gynecologist appointment today for my iud. My anxiety is through the roof. I can't even deal with the travel right now... any thought of going to that appointment brings panic through my body. I'll try again, but not today. #survivorculture #MeToo
- I have been asking media houses to debate this but these spineless guys don't ever discuss such incidents. Biased media could only talk #MeToo at prime time to demean the men of this country. Poor guard with no mistake is behind bars . Jago Jago @Dev_Fadnavis @CMOMaharashtra
- If these same signs had pictures of transgender African Americans holding #metoo signs, there would be rioting, looting, and protests. The right would be called white supremacists and nazis for it. The double standard is real and easy to see.
- @Annamahof1 @Gatonyenn @Darius_M4 The question wasn't about if women are dangerous or not, it was if women are more agreeable than men, don't change the topic. The answer is NO -Men give more present than Women -Men help more others on their works -Men don't do #metoo -Men don't ask for divorce at 75
- If a woman shares a #metoo without evidence, it's taken to be true coz it's a women's testimony, a man coming out with #HeToo story, people would be doubtful, & question the evidences, the intent & will never except the man as victim. #misandry must be understood. #SpeakUpMan

Summary produced by applying Equal Representation on proposed FairSumm Algorithm (10 tweets by Females & 10 tweets by Males) [Algorithm I]

- I need influencers to help me get the word out. I need 1000s if people to follow me & RT. I need a Dateline long format interview & to talk to Oprah. I need funding and support. I am Alex Jones ex-wife & I am NOT the underdog. I am you. I am America, #metoo & can change this.
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- It is not just Suhel Seth's silence. It's also the unacceptable silence of many in media who knew him professionally and socially. I did too like many others. I spoke up but I can count on one hand those of us who have demanded accountability from him #MeToo : Where are others?
- @SenatorCollins Too bad you don't really believe in the power of truth. How can you live with yourself, knowingly voting for an alcoholic abuser of women. Next time I am sexually assaulted I will first ask if anyone would like to witness for prosperity's sake #metoo screw you.
- I for one believe all women which is why i will believe this Mueller accuser until it is proven she is or isn't lying. Sure is odd All the media is trying to get out in front of this before we even have the accuser's name though for those noting.. #Metoo
- A year ago today I thought my world was falling apart. I woke up to find out that the hashtag #metoo had gone viral and I didn't see any of the work I laid out over the previous decade attached to it. I thought for sure I would be erased from a thing I worked so hard to build.
- I admire the courage of @priyaramani & all the victims who spoke out against sexual harassment & abuse. @mjakbar s resignation is a moral victory for everyone. The defamation case cant change that. The #MeToo movement needs support across party lines.
- @MIKENY78 @SmartKehan @MailOnline That to they lied and now they want to lynch every Man on Earth . The Whole #metoo is Stupid . Its Dangerous to believe every woman . No Man is safe anymore when someone doesnt like you they cry #metoo . It can happen to everyone
- @varshapillai @womensweb Are women that weak that they need a hashtag to speak out ? I'm sure women are strong enough to fight without social media. Atleast women around me are. #metoo needs to be stopped because it does really promote more fake cases. Instead fight the real one bravely and we support u.
- As I cry and succumb to mental exhaustion because of #MeToo , I remember the friendships women forged and solidarity we showered upon each other. Each one of you who has helped, supported, fought the war, been there

relentlessly - I will never forget. Thank you. I love you.

- She has no cellphone and doesn't use hashtags. "What is misleading is that people say #MeToo is an urban elite thing that must reach the poor. It's actually the other way around." 'They Deserve Justice': Mother Of India's #MeToo Speaks Out
- Excellent news Should have happened right away but good that it happened now Thanks to @TataCompanies for doing the right thing Meanwhile Suhel Seth continues to hide in whatever hole he's crawled into #MeToo.
- Im so fucking stupid everyone always says dont get in a strangers car. Im fucking smarter than this. I hate this world you can never trust anyone Im fine, he just tried to hold my hand, put his hand on my leg. I got home safely but still... he was 60 and Im 17 #metoo
- These wounds come from a culture infection; we know where it began. It's effects has lasted for generations and the time to cleanse it all out is now. This isn't our shame to hold any longer. This was never ours to begin with. #IndigenousMeToo #Indigenous #MeToo
- If a guy says he's nervous about #MeToo, just remind him that we come down pretty hard on murderers too, and ask him why that doesn't make him nervous. If he says, "Because I haven't murdered anyone," then you've learned something new about your friend.
- I had to cancel a follow up gynecologist appointment today for my iud. My anxiety is through the roof. I can't even deal with the travel right now... any thought of going to that appointment brings panic through my body. I'll try again, but not today. #survivorculture #MeToo
- We need to send out the message This not how we behave in our sector. Brave words from @shyhousinggirl. @LuchiaFitz100 and I have been calling for such action daily @24housing Opinion #MeToo movement in housing: Are we standing up for change?
- If these same signs had pictures of transgender African Americans holding #metoo signs, there would be rioting, looting, and protests. The right would be called white supremacists and nazis for it. The double standard is real and easy to see.
- @Annamahof1 @Gatonyenn @Darius_M4 The question wasn't about if women are dangerous or not, it was if women are more agreeable then men, don't change the topic. The answer is NO -Men give more present than Women -Men help more others on their works -Men don't do #metoo -Men don't ask for divorce at 75
- If a woman shares a #metoo without evidence, it's taken to be true coz it's a women's testimony, a man coming out with #HeToo story, people would be doubtful, & question the evidences, the intent & will never except the man as victim. #misandry must be understood. #SpeakUpMan

2.2 Summaries of US-Election Dataset

Here are few summaries (of length $k = 20$ tweets) produced with different fairness constraints of the US-Election Dataset.

Summaries produced by Sumbasic Algorithm: (3 pro-democratic tweets & 15 pro-republican tweets & 2 neutral tweets)

- There is no other Donald Trump. This is it.
- REPEAL AND REPLACE!!! #ObamaCareInThreeWords
- 13 states have voter registration deadlines TODAY: FL, OH, PA, MI, GA, TX, NM, IN, LA, TN, AR, KY, SC.
- COMING UP @GenFlynn @newtingrich on @foxandfriends
- "A rough night for Hillary Clinton" ABC News.
- There's only one candidate in this election who's ready to be America's Commander-in-Chief.
- Barack& Michelle& Joe& Bernie& Elizabeth& You?
- Crooked Hillary Clinton likes to talk about the things she will do but she has been there for 30 years - why didn't she do them?
- That was me! I was there...
- MAKE AMERICA GREAT AGAIN!
- 'Donald Trump: A President for All Americans'
- Do you think Hillary has all the questions that she is going to be asked debate Retweet before you vote to give your people a chance to vote
- The media and establishment want me out of the race so badly - I WILL NEVER DROP OUT OF THE RACE,

WILL NEVER LET MY SUPPORTERS DOWN! #MAGA

- We call on the FBI to immediately release all emails pertinent to their investigation. Americans have the right to know before Election Day.
- #NEW Reuters/Ipsos Polls #Iowa: Trump 49% (+8) Clinton 41% #Florida: Trump 50% (+4) Clinton 46% #Colorado Trump 43% (+3) Clinton 40%
- Thank you to @foxandfriends for the great review of the speech on immigration last night. Thank you also to the great people of Arizona!
- Russia took Crimea during the so-called Obama years. Who wouldn't know this and why does Obama get a free pass?
- Praying for the families of the two Iowa police who were ambushed this morning. An attack on those who keep us safe is an attack on us all.
- @realDonaldTrump campaign raised a record \$100 million in September. Number of donors up 25%.
- my son is voting for the first time i'm so proud

Summary produced by applying Proportional Representation on FairSumm Algorithm (6 pro-democratic tweets & 12 pro-republican tweets& 2 neutral tweets) [Algorithm I]

- You can change your vote in six states. So, now that you see that Hillary was a big mistake, change your vote to MAKE AMERICA GREAT AGAIN!
- Wow, Hillary Clinton was SO INSULTING to my supporters, millions of amazing, hard working people. I think it will cost her at the Polls!
- WHY ARE PEOPLE VOTING TRUMP BECAUSE "HILLARY IS A CRIMINAL" WHEN THE FBI ALREADY CLEARED HER AND TRUMP IS GOING TO COURT FOR A RAPE CLAIM
- Donald Trump still refuses to say @POTUS was born in America. And this man wants to be our president? When will he stop this ugliness?
- Just heard from NC Campaign. Hillary Campaign is calling voters saying they have a chance to win \$5k if they vote Hillary! Paying 4 votes!
- Voter fraud! Crooked Hillary Clinton even got the questions to a debate, and nobody says a word. Can you imagine if I got the questions?
- Trump said his campaign could be his "single greatest waste of time, of energy & money." Congrats, Donald! Today you are a Trump U graduate.
- In order to #DrainTheSwamp & create a new GOVERNMENT of, by, & for the PEOPLE, I need your VOTE! Go to - LET'S #MAGA!
- Imagine if Hillary Clinton said on her email server - "I don't talk about it anymore." And we all just moved on. That's not how it works.
- As @realDonaldTrump just showed the American people, no matter what happens he will not be deterred & he will not give up fighting for you!
- Wow, did you just hear Bill Clinton's statement on how bad ObamaCare is. Hillary not happy. As I have been saying, REPEAL AND REPLACE!
- Hearing privately from many reporters that Hillary had a "terrible night" & Trump had best debate. Hope this will make it into print, on air
- Hillary Clinton didn't go to Louisiana, and now she didn't go to Mexico. She doesn't have the drive or stamina to MAKE AMERICA GREAT AGAIN!
- The people are really smart in cancelling subscriptions to the Dallas & Arizona papers & now USA Today will lose readers! The people get it!
- Hey everyone, the Obama speechwriters who came up with "If you like your plan you can keep it" are saying Hillary's health is just fine.
- We hear Hillary will try to get under Trump's skin tomorrow night. How does this differ with what she does to all of us daily? #Debates
- The fact that Trump's answer to a question about racial injustice is just "we need law and order" pretty much says it all. #debatenight
- Win or lose, Trump made our world uglier. I don't want any reality shows from him after this, no cutesy late night sketches. I want nothing.
- How are so many people JUST NOW offended by Trump? It's like getting to the 7th Harry Potter book &

realizing Voldemort might be a bad guy.

- "I call on all Republicans to put people before politics and finally vote on a clean funding bill to fight Zika right here in Florida."

Summary produced by applying Equal Representation on FairSumm Algorithm (7 pro-democratic tweets & 7 pro-republican tweets & 6 neutral tweets) [Algorithm I]

- You can change your vote in six states. So, now that you see that Hillary was a big mistake, change your vote to MAKE AMERICA GREAT AGAIN!
- Wow, Hillary Clinton was SO INSULTING to my supporters, millions of amazing, hard working people. I think it will cost her at the Polls!
- WHY ARE PEOPLE VOTING TRUMP BECAUSE "HILLARY IS A CRIMINAL" WHEN THE FBI ALREADY CLEARED HER AND TRUMP IS GOING TO COURT FOR A RAPE CLAIM
- Donald Trump still refuses to say @POTUS was born in America. And this man wants to be our president? When will he stop this ugliness?
- Voter fraud! Crooked Hillary Clinton even got the questions to a debate, and nobody says a word. Can you imagine if I got the questions?
- In order to #DrainTheSwamp & create a new GOVERNMENT of, by, & for the PEOPLE, I need your VOTE! Go to - LET'S #MAGA!
- Imagine if Hillary Clinton said on her email server - "I don't talk about it anymore." And we all just moved on. That's not how it works.
- As @realDonaldTrump just showed the American people, no matter what happens he will not be deterred & he will not give up fighting for you!
- Wow, did you just hear Bill Clinton's statement on how bad ObamaCare is. Hillary not happy. As I have been saying, REPEAL AND REPLACE!
- The people are really smart in cancelling subscriptions to the Dallas & Arizona papers & now USA Today will lose readers! The people get it!
- We have to stand up to this hate. We have to send a clear message: America is better than this. America is better than Donald Trump.
- Trump surrogates now attacking former Miss Universe 4 doing a nude photo spread. You know, just like Melania Trump did. Do they ever think?
- Trump said his campaign could be his "single greatest waste of time, of energy & money." Congrats, Donald! Today you are a Trump U graduate.
- Win or lose, Trump made our world uglier. I don't want any reality shows from him after this, no cutesy late night sketches. I want nothing.
- How are so many people JUST NOW offended by Trump? It's like getting to the 7th Harry Potter book & realizing Voldemort might be a bad guy.
- "I call on all Republicans to put people before politics and finally vote on a clean funding bill to fight Zika right here in Florida."
- It happened: @Cubs win World Series. That's change even this South Sider can believe in. Want to come to the White House before I leave?
- Trump: I alone can fix! Hillary: Together we can fix it! Stein: They can't fix it and neither can I! Johnson: [Googles definition of fix]
- If Hillary wins- God is still God If Trump wins- God is still God I may have lost hope in America, but never in God.
- Thank you to every nation that moved to bring the Paris Agreement into force. History will judge today as a turning point for our planet.

NOTE: The difference in length of tweets in the MeToo dataset and that of US-Election dataset is due to the change in the maximum number of characters allowed in a tweet from 140 to 280 in the year 2017.

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- [3] Nan Du, Yingyu Liang, Maria-Florina Balcan, and Le Song. Continuous-time influence maximization for multiple items. *CoRR*, abs/1312.2164, 2013.