TEXT OVERLAP PATTERNS IN SCIENTIFIC LITERATURE:

MEASURING AND INTERPRETING PLAGIARISM ON ARXIV

Daniel T. Citron

Paul Ginsparg
Department of Physics, Cornell University
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Background: What is arXiv?

- www.arXiv.org
- Created by Paul Ginsparg
- Repository of scientific articles, hosted by Cornell's library
- Established 1991
- 849,000 submissions as of May 2013
- ~85,000 new submissions in 2012

Plagiarism case in 2007

- Middle East Technical University in Turkey
- Physics theorist grad student had considerable publications record
  - 40 submissions to arXiv in 22 months
- During B exam, committee member began to suspect a lack of necessary language skills…
- Upon closer examination, it was found that the submitted papers contained mostly borrowed text and few original ideas or work.
- Papers were later removed from arXiv
  - One is still available from *J. High Energy Physics*

- Collection of all papers removed due to plagiarism:
  http://arxiv.org/new/withdrawals.aug.07.html

Questions Prompted

- How common is behavior like this?
  - Is reuse of text from other publications normal or not?
  - What should our standards for “normal” be?
- How many people engage in this behavior?
  - Does everyone do it some of the time?
  - Are there serial copiers? If so, how do we find them?
- To what extent is this behavior an indicator of quality?
  - Do important articles reuse text from other articles?
  - Do prominent researchers habitually reuse text?
- How do we analyze the arXiv to find answers to these questions?

Clarifications about "Plagiarism"

- OED: "The action or practice of taking someone else's work, idea, etc., and passing it off as one's own; literary theft"
- Text reuse is a mode of plagiarism
  - Our methods detect text overlaps, not idea overlaps
  - Not all plagiarism cases can be found using our methods
- We do not attempt to interpret motivation for text reuse:
  - Cheating with intent to steal ideas
  - Inflation of publication records
  - Republishing previous results with slight updates
  - Two experimental papers can have identical procedures, boilerplate
- **We do not mean to disparage researchers of their practices. We can only make empirical statements about observed patterns in text reuse.**

How do we detect text overlaps?

- Need to pairwise compare text from all ~1M articles
- $O(1M^2)$ comparisons is very expensive…
- Decrease computation time using hashing scheme
  1. Identify a characteristic subset of 7-grams
     E.g. "We first consider two point-like proteins"
     E.g. ~~"In this paper we discuss"~~
  2. Ignore common phrases used by many non-overlapping authors
     E.g. ~~"We verify these calculations using Monte Carlo"~~
  3. Obtain a hash "fingerprint" summarizing the text content
- Compute pairwise overlaps between *fingerprints* of all papers

Text examples taken from: Machta,B.B., Veatch, S.L., Sethna, J.P. Critical Casimir forces in cellular membranes. *Physical Review Letters* **109**, 138101(2012)
<http://arxiv.org/pdf/1203.2199.pdf>

Example of Text Overlap

arXiv:1203.2199v2 (change)	arXiv:1009.2095v1 (change)
Critical Casimir forces in cellular membranes Machta, Veatch, Sethna	**A minimal model of plasma membrane heterogeneity requires coupling cortical actin to criticality** Machta, Papanikolaou, Sethna, Veatch
Matching blocks include 7 of the document's 3170 words (0.221%) Longest matching block is 7 words	Matching blocks include 7 of the document's 10434 words (0.0671%) Longest matching block is 7 words
... proteins couple to their surrounding composition through the height of their hydrophobic regions interactions of their membrane proximal amino acids with their closest lipid shell and by covalent attachment to certain lipids which themselves strongly segregate into one of the two low temperature phases ...	... we pin pixels of the same type white presuming that the interaction with the cytoskeleton prefers one of the two low temperature phases ...

Contact

- Generated on arXiv's website
- Red indicates overlapping portions of text
  - In this case, only 1 7-gram in common between the two papers

Another Example of Text Overlap

arXiv:0907.2491v2 (change)	arXiv:0909.0302v2 (change)
Interacting agegraphic tachyon model of dark energy Sheykhi	**Interacting agegraphic quintessence dark energy in non-flat universe** Sheykhi, Bagheri, Yazdanpanah
Matching blocks include 1330 of the document's 2679 words (49.6%) Longest matching block is 139 words	Matching blocks include 1280 of the document's 3207 words (39.9%) Longest matching block is 134 words
...	...
department of physics shahid bahonar university box kerman iran research institute for astronomy and astrophysics of maragha riaam maragha iran scalar field dark energy models like tachyon are often regarded as an effective description of an underlying theory of dark energy	sheykhia bagheria and yazdanpanaha adepartment of physics shahid bahonar university box kerman iran bresearch institute for astronomy and astrophysics of maragha riaam maragha iran
...	...
we demonstrate that the interacting agegraphic evolution of the universe can be described completely by single tachyon scalar field	we demonstrate that the agegraphic evolution of the universe can be described completely by single quintessence scalar field
we thus reconstruct the potential as well as the dynamics of the tachyon field according to the evolutionary behavior of interacting agegraphic dark energy	then we reconstruct the potential of the interacting agegraphic quintessence dark energy as well as the dynamics of the scalar field according to the evolution of the agegraphic dark energy
	...
introduction great variety of cosmological observations direct and indirect reveal that our universe is currently experiencing phase of accelerated expansion	it is general belief that our universe is currently experiencing phase of accelerated expansion
component which causes cosmic acceleration is usually dubbed dark energy which constitute ma jor puzzle of modern cosmology	missing energy component with negative pressure which is responsible for this expansion constitute ma jor puzzle of modern cosmology
...	...
	among the various candidates to explain the accelerated expansion the cosmological constant with is located at central position
though it suffers the so called fine tuning and cosmic coincidence problems	though it suffers the so called fine tuning and cosmic coincidence problems
	...
among different candidates for probing the nature of dark energy the holographic dark energy model arose lot of enthusiasm recently	an interesting attempt for probing the nature of dark energy within the framework of quantum gravity is the holographic dark energy
this model is motivated from the holographic hypothesis and has been tested and constrained by various astronomical observations	this proposal that arose lot of enthusiasm recently is motivated from the holographic hypothesis and has been tested and constrained by various astronomical observations
however there are some difficulties in holographic dark energy model	however there are some difficulties in holographic dark energy model
choosing the event horizon of the universe as the length scale the holographic dark energy gives the observation value of dark energy in the universe and can drive the universe to an accelerated expansion phase	choosing the event horizon of the universe as the length scale the holographic dark energy gives the observation value of dark energy in the universe and can drive the universe to an accelerated expansion phase
but an obvious drawback concerning causality appears in this proposal	but an obvious drawback concerning causality appears in this proposal

Another Example of Text Overlap (cont'd)

event horizon is global concept of spacetime existence of event horizon of the universe depends on future evolution of the universe and event horizon exists only for universe with forever accelerated expansion

in addition more recently it has been argued that this proposal might be in contradiction to the age of some old high redshift ob jects unless lower hubble parameter is considered

an interesting proposal to explore the nature of dark energy within the framework of quantum gravity is so called agegraphic dark energy ade

this model takes into account the heisenberg sheykhi mail uk ac ir uncertainty relation of quantum mechanics together with the gravitational effect in general relativity

the ade model assumes that the observed dark energy comes from the spacetime and matter field fluctuations in the universe

since in ade model the age of the universe is chosen as the length measure instead of the horizon distance the causality problem in the holographic dark energy is avoided

the agegraphic models of dark energy have been examined and constrained by various astronomical observations

although going along fundamental theory such as quantum gravity may provide hopeful way towards understanding the nature of dark energy it is hard to believe that the physical foundation of ade is convincing enough

indeed it is fair to say that almost all dynamical dark energy models are settled at the phenomenological level neither holographic dark energy model nor ade model is exception

though under such circumstances the models of holographic and ade to some extent still have some advantage comparing to other dynamical dark energy models because at least they originate from some fundamental principles in quantum gravity

on the other hand among the various candidates to explain the accelerated expansion the rolling tachyon condensates in class of string theories may have interesting cosmological consequences

...

event horizon is global concept of spacetime existence of event horizon of the universe depends on future evolution of the universe and event horizon exists only for universe with forever accelerated expansion

in addition more recently it has been argued that this proposal might be in contradiction to the age of some old high redshift ob jects unless lower hubble parameter is considered

another proposal to probe the nature of dark energy within the framework of quantum gravity is so called agegraphic dark energy ade

this model is based on the uncertainty relation of quantum mechanics together with the gravitational effect in general relativity

following the line of quantum fluctuations of spacetime karolyhazy et al

argued that the distance in minkowski spacetime cannot be known to better accuracy than where is dimensionless constant of order unity

based on karolyhazy relation

maziashvili discussed that the energy density of metric fluctuations of the minkowski spacetime is given by where tp is the reduced planck time

...

the agegraphic dark energy model assumes that the observed dark energy comes from the spacetime and matter field fluctuations in the universe

since in agegraphic dark energy model the age of the universe is chosen as the length measure instead of the horizon distance the causality problem in the holographic dark energy is avoided

the agegraphic models of dark energy have been examined and constrained by various astronomical observations

although going along fundamental theory such as quantum gravity may provide hopeful way towards understanding the nature of dark energy it is hard to believe that the physical foundation of agegraphic dark energy is convincing enough

indeed it is fair to say that almost all dynamical dark energy models are settled at the phenomenological level neither holographic dark energy model nor agegraphic dark energy model is exception

though under such circumstances the models of holographic and agegraphic dark energy to some extent still have some advantage comparing to other dynamical sheykhi mail uk ac ir myazdan mail uk ac ir dark energy models because at least they originate from some fundamental principles in quantum gravity

we thus may as well view that this class of models possesses some features of an underlying theory of dark energy

on the other hand the scalar field model is an effective description of an underlying

Another Example of Text Overlap (cont'd)

...

therefore it becomes meaningful to reconstruct tachyon potential from some dark energy models possessing some significant features of the quantum gravity theory such as holographic and ade models

...

the investigations on the reconstruction of the tachyon potential in the framework of holographic dark energy have been carried out in

in the absence of the interaction between ade and dark matter the connection between tachyon field and the new ade model has also been established in

in the present letter we would like to extend the study to the case where both components the pressureless dark matter and the ade do not conserve separately but interact with each other

given the unknown nature of both dark matter and dark energy there is nothing in principle against their mutual interaction and it seems very special that these two ma jor components in the universe are entirely independent

we shall establish correspondence between the interacting ade scenarios and the tachyon scalar field in non flat universe

...

we suggest the agegraphic description of the tachyon dark energy in universe with spacial curvature and reconstruct the potential and the dynamics of the tachyon scalar field which describe the tachyon cosmology

...

in section iii we establish the correspondence between the new model of interacting ade and the tachyon dark energy

the last section is devoted to conclusions

...

we consider the friedmann robertson walker frw universe which is described by the line element cid dr kr cid where is the scale factor and is the curvature parameter with corresponding to open flat and closed universes respectively

closed universe with small positive curvature ds dt is compatible with observations

...

we define as usual the fractional energy densities such as ph thus the friedmann equation can be written ph

on the other hand the scalar field model is an effective description of an underlying theory of dark energy

...

therefore it becomes meaningful to reconstruct from some dark energy models possessing some significant features of the quantum gravity theory such as holographic and agegraphic dark energy model

the investigations on the reconstruction of the potential in the framework of holographic dark energy have been carried out in

in the absence of the interaction between agegraphic dark energy and dark matter the quintessence reconstruction of the agegraphic dark energy models have been established

in this paper we intend to generalize the study to the case where both components the pressureless dark matter and the agegraphic dark energy do not conserve separately but interact with each other

given the unknown nature of both dark matter and dark energy there is nothing in principle against their mutual interaction and it seems very special that these two ma jor components in the universe are entirely independent

we shall establish correspondence between the interacting agegraphic dark energy scenarios and the quintessence scalar field

we suggest the agegraphic description of the quintessence dark energy in universe with spacial curvature and reconstruct the potential and the dynamics of the quintessence scalar field which describe the quintessence cosmology

...

in section iii we establish the correspondence between the new model of interacting agegraphic dark energy and the quintessence dark energy

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...

we assume the agegraphic quintessence dark energy is accommodated in the friedmann robertson walker frw universe which is described by the line element cid dr kr cid where is the scale factor and is the curvature parameter with corresponding to open flat and closed universes respectively

closed universe with small positive curvature is compatible with observations

...

we introduce as usual the fractional energy densities such as ph ph thus the friedmann equation can be written

Another Example of Text Overlap (cont'd)

we adopt the viewpoint that the scalar field models of dark energy are effective theories of an underlying theory of dark energy

the energy density and pressure for the tachyon scalar field can be written as

...

following the line of quantum fluctuations of spacetime karolyhazy et al

argued that the distance in minkowski spacetime cannot be known to better accuracy than where is dimensionless constant of order unity

based on karolyhazy relation maziashvili discussed that the energy density of metric fluctuations of the minkowski spacetime is given by where tp is the reduced planck time and is proper time scale

...

cai proposed the dark energy density of the form where is chosen to be the age of the universe

thus he wrote down the energy density of the original ade as da where the numerical factor is introduced to parameterize some uncertainties such as the species of quantum fields in the universe the effect of curved space time and so on

the dark energy density has the same form as the holographic dark energy but the length measure is chosen to be the age of the universe instead of the horizon radius of the universe

thus the causality problem in the holographic dark energy is avoided

combining equation and we get

the total energy density is where and are the energy density of dark matter and dark energy respectively

the total energy density satisfies conservation law

however since we consider the interaction between dark matter and dark energy and do not conserve separately they must rather enter the energy balances wd

here wd is the equation of state parameter of ade and denotes the interaction term and can be taken as with being coupling constant

taking the derivative with respect to the cosmic time of equation and using equation we get

inserting this relation into equation we obtain the equation of state parameter of the original ade in non flat universe wd

differentiating equation and using relation

we adopt the viewpoint that the scalar field models of dark energy are effective theories of an underlying theory of dark energy

the energy density and pressure for the quintessence scalar field can be written as

...

the original agegraphic dark energy density has the form where is chosen to be the age of the universe

thus the energy density of the original agegraphic dark energy is given by da where the numerical factor is introduced to parameterize some uncertainties such as the species of quantum fields in the universe the effect of curved space time since the energy density is derived for minkowski space time and so on

the dark energy density has the same form as the holographic dark energy but the length measure is chosen to be the age of the universe instead of the horizon radius of the universe

thus the causality problem in the holographic dark energy is avoided

combining equation and we get

the total energy density is where and are the energy density of dark matter and dark energy respectively

the total energy density satisfies conservation law

however since we consider the interaction between dark matter and dark energy and do not conserve separately they must rather enter the energy balances wd

here wd is the equation of state parameter of agegraphic dark energy and denotes the interaction term and can be taken as with being coupling constant

...

taking the derivative with respect to the cosmic time of equation and using equation we get

inserting this relation into equation we obtain the equation of state parameter of the original agegraphic dark energy wd

differentiating equation and using relation

Another Example of Text Overlap (cont'd)

dh we reach where the dot and the prime stand for the derivative with respect to the cosmic time and the derivative with respect to ln respectively

taking the derivative of both side of the friedman equation with respect to the cosmic time and using equation and it is easy to show that

substituting this relation into equation we obtain the equation of motion for the original ade cid cid

...

now we suggest correspondence between the original ade and tachyon scalar field namely we wd ph and equation and we can find identify with

...

consequently we can easily obtain the evolutionary form of the tachyon field by integrating the above equation where is the value of the scale factor at the present time is given by equation and can da be extracted from equation

...

therefore we have established an interacting agegraphic tachyon dark energy model and recon dt

structed the potential and the dynamics of the tachyon field

...

substituting this relation into equation we obtain cid

...

to avoid some internal inconsistencies in the original ade model the so called new agegraphic dark energy was proposed where the time scale is chosen to be the conformal time instead of the age of the universe

the new ade contains some new features different from the original

...

for instance the original ade suffers from the difficulty to describe the matter dominated epoch while the new ade resolved this issue

the energy density of the new ade can be written where the conformal time is given by dt

the fractional energy density of the new ade is now expressed as da

taking the derivative with respect to the cosmic time of equation and using equation we get na

inserting this relation into equation we obtain the equation of state parameter of the new ade wd na

dh we reach where the dot and the prime stand respectively for the derivative with respect to the cosmic time and the derivative with respect to ln taking the derivative of both side of the friedman equation with respect to the cosmic time and using equation and it is easy to show that

substituting this relation into equation we obtain the equation of motion of agegraphic dark energy cid cid

...

now we suggest correspondence between the original agegraphic dark energy and quintessence scalar field namely we identify with

...

consequently we can easily obtain the evolutionary form of the field by integrating the above equation r mp where is the present value of the scale factor and is given by equation

therefore we have established an interacting agegraphic quintessence dark energy model and reconstructed the potential of the agegraphic quintessence as well as the dynamics of scalar field

...

soon after the original agegraphic dark energy model was introduced by cai new model of agegraphic dark energy was proposed in while the time scale is chosen to be the conformal time instead of the age of the universe

...

the new agegraphic dark energy contains some new features different from the original agegraphic dark energy and overcome some unsatisfactory points

for instance the original agegraphic dark energy suffers from the difficulty to describe the matter dominated epoch while the new agegraphic dark energy resolved this issue

the energy density of the new agegraphic dark energy can be written where the conformal time is given by dt

the fractional energy density of the new agegraphic dark energy is now given by da

...

taking the derivative with respect to the cosmic time of equation and using equation we get na

...

inserting this relation into equation we obtain the equation of state parameter of the new agegraphic dark energy wd na

Another Example of Text Overlap (cont'd)

...
using equation and one can easily show that the tachyon potential and kinetic energy term take the following form ph cid na cid cid na

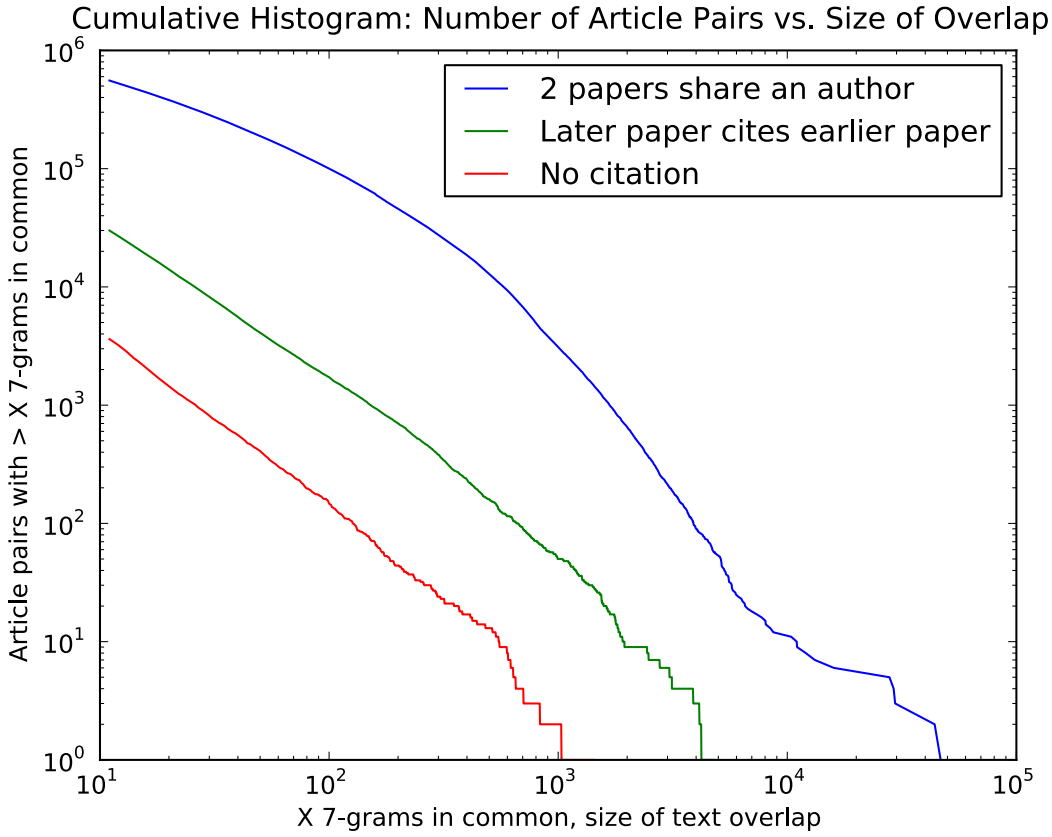
we can also rewrite equation as cid cid na
therefore the evolution behavior of the tachyon field can be obtained by integrating the above cid equation or in another way na da na where is now given by equation
in this way we connect the interacting new ade with dt
tachyon field and reconstruct the potential and the dynamics of the tachyon field which describe tachyon cosmology
...
the ade models take into account the heisenberg uncertainty relation of quantum mechanics together with the gravitational effect in general relativity
these models assume that the observed dark energy comes from the spacetime and matter field fluctuations in the universe
therefore agegraphic scenarios may possess some significant features of an underlying theory of dark energy
we have demonstrated that the agegraphic evolution of the universe can be described completely by tachyon scalar field in certain way
we have adopted the viewpoint that the scalar field models of dark energy are effective theories of an underlying theory of dark energy
thus we should be capable of using the scalar field model to mimic the evolving behavior of the interacting ade and reconstructing this scalar field model

...
using equation and one can easily show that the scalar potential and kinetic energy term take the following form ph cid cid na cid mph cid na
...
we can also rewrite equation as cid mp cid na
therefore the evolution behavior of the scalar field can be obtained by integrating the above equation r mp na where is now given by equation
in this way we connect the interacting agegraphic dark energy with quintessence scalar field and reconstruct the potential of the agegraphic quintessence
...
we have demonstrated that the agegraphic evolution of the universe can be described completely by single quintessence scalar field
we have adopted the viewpoint that the scalar field models of dark energy are effective theories of an underlying theory of dark energy
if we regard the scalar field model as an effective description of such theory we should be capable of using the scalar field model to mimic the evolving behavior of the interacting agegraphic dark energy and reconstructing this scalar field model according to the evolutionary behavior of agegraphic dark energy
we have also reconstructed the potential of the agegraphic scalar field as well as the dynamics of the quintessence scalar field which describe the quintessence cosmology
...
karolyhazy nuovo cim
karolyhazy frenkel and lukacs in physics as natural philosophy edited by shimony and

- The two papers in this example:
  - One author in common
  - Submitted 2 months apart
  - ~1300 words in common, > 40% of complete text of each article
- **We focus on cases like these, with large amounts of overlapping text**

Distribution of Overlap Sizes

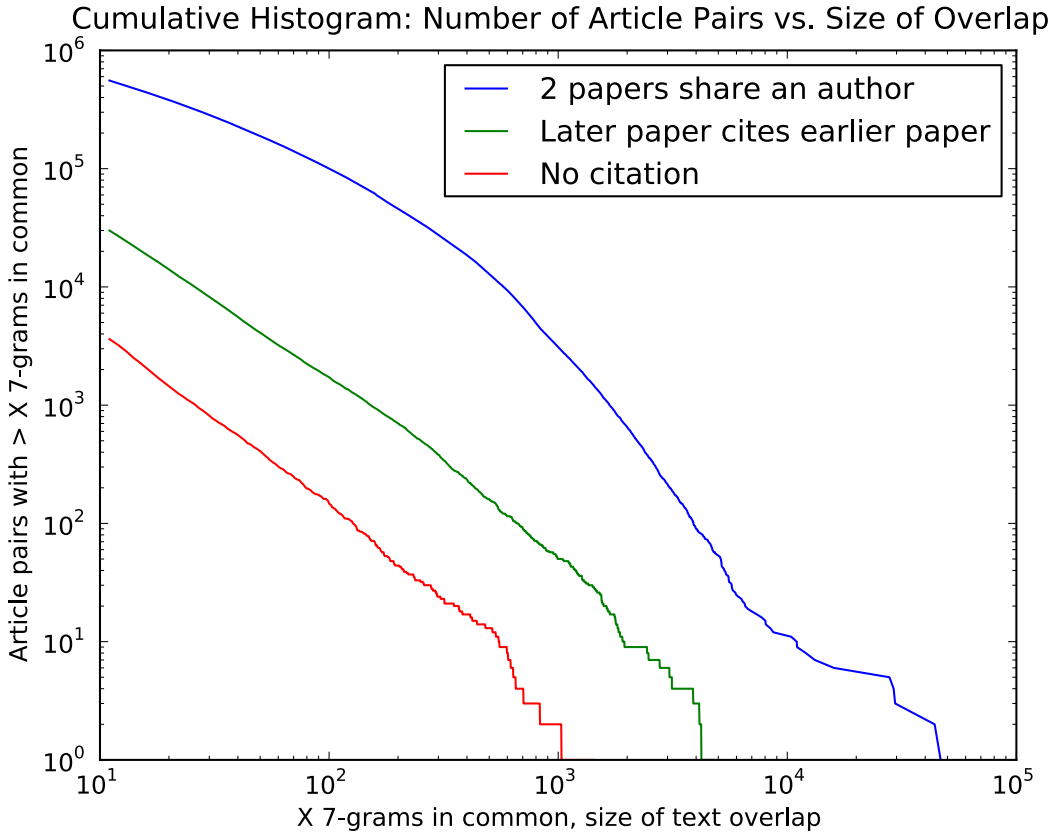
- Cumulative histogram of **article pairs** with overlap ≥X 7-grams
  - Blue: Author in common
  - Green: No common authors, later paper cites earlier paper
  - Red: No common authors, no citations
- Example: ~100,000 cases of papers reusing ≥100 7-grams from another paper



Distribution of Overlap Sizes

- Good news
  - Copying without citing others is relatively rare
  - Most cases of text copying are for small amounts of text, a few 10s of words
- Bad news
  - Still many cases of large amounts of text overlap

  (see heavy tail, toward right)

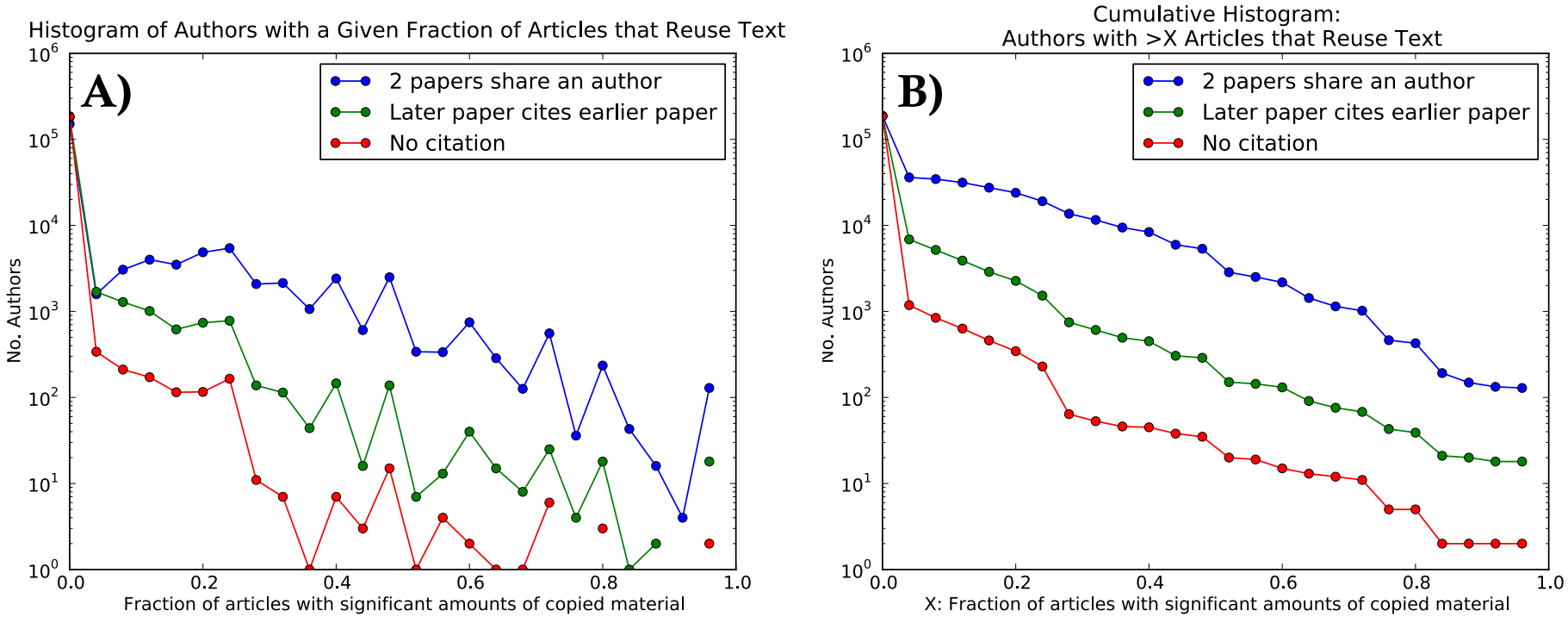


Distribution of Overlaps

- Who is responsible for the text overlaps shown on the previous slide?
  - We know how many papers and authors there are
  - We know how many overlap instances there are
  - So how are those overlaps distributed among the authors?
- For each author:
  - Identify all papers
  - Count fraction of author's papers with text copied from elsewhere

    i.e. an author's tendency to reuse text
  - Allows us to measure distribution of authors' tendency to copy

Distribution of overlaps



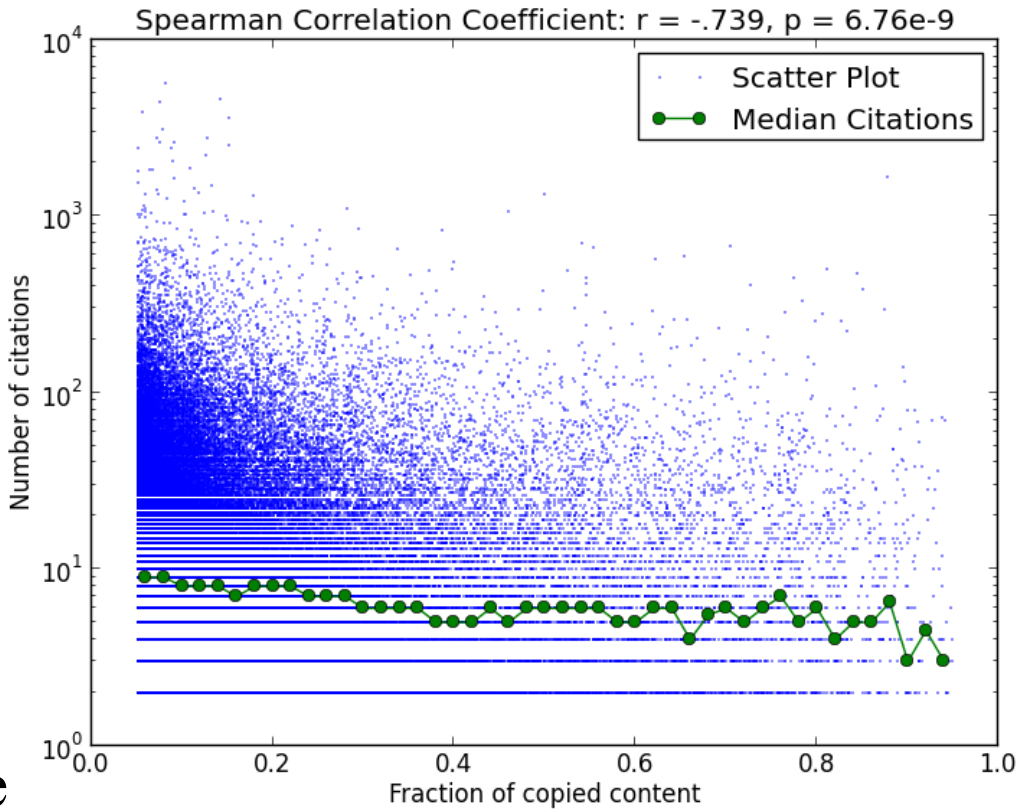
- **A)** Histogram – authors with a given fraction of articles that reuse text
- **B)** Cumulative histogram – authors with fraction ≥X articles that reuse text
- Bimodal distribution (Note: semilog y-axis)
  - Vast majority of authors have no text reuse
  - Tail of distribution represents a minority of authors who copy

Text Reuse as an Indicator of Article Quality

- Does reuse of text indicate lower article quality?
- Use citations count as an indicator of a paper's influence
- Measure correlations between text reuse and citations
  - Focus on subset of 116,000 papers with full citation data known
  - Focus on papers written before January 2011
  - Discount self-citations by authors of their own work; citations by others is a better indicator of importance or influence

Text Reuse as an Indicator of Article Quality

- Blue: Scatter data of citations vs. fraction of copied content for all articles
- Green: Median citations
- Note negative correlation: Papers with large amounts of copied content receive fewer citations
- Articles with large amounts of copied content are not the ones receiving a lot of attention



Summary and Conclusions

- arXiv has a new tool that efficiently detects papers that have borrowed large amounts of text from other papers
- We have examined the frequency and distribution of these incidences of text reuse
  - Occurrences of text reuse are common
  - A small minority of authors is responsible for the majority of cases of large text overlaps
  - Suggests that, generally, the scientific community at least tacitly adheres to a standard of avoiding text reuse
- Frequent text reuse is correlated with fewer citations
  - Suggests that the papers that reprint older material are not the focus of the research community's interest

Further Work

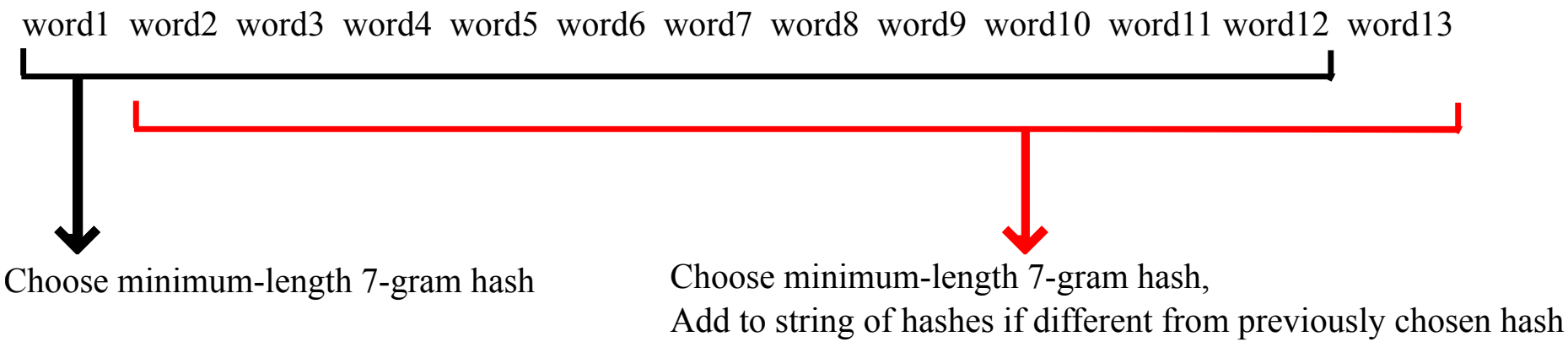
- Hand off project to sociology/bibliometry
  - Familiar with general trends in citations practices
  - Familiar with motivation or psychology of plagiarism
  - Familiar with international differences in publications practices
  - Equipped to carry out ethnographic studies of small groups of authors
- Examine higher-order network structure:
  - Current methods only detect pairwise overlaps
  - Triangles can lead to false positives

Acknowledgements and Citations

- Principal investigator: Paul Ginsparg
- Former collaborators: Daria Sorokina, Johannes Gehrke, Simeon Warner

- Timmer, John. “Plagiarism and falsified data slip into the scientific literature: a report.” *Ars Technica*. 8 Aug. 2007. Web. 10 Oct. 2012. http://arstechnica.com/features/2007/08/plagiarism-and-falsified-data-slip-into-the-scientific-literature/
- Sorokina et. al. “Plagiarism Detection in arXiv.” In proceedings of the 6th IEEE International Conference on Data Mining (ICDM’06)

Details of Winnowing Algorithm



- Algorithm outline:
  - Look at 6 consecutive 7-grams (12 words)
  - Deterministically hash each 7-gram, pick shortest (least memory) hash
  - Examine next group of 7-grams, pull out shortest (least memory) hash
  - Compare consecutive hashes: add hash to hash string if different from previous
- Results in a series of minimum-length hashes that represents the full text content of the paper
- Hashing reduces number of words by factor of ~3.6
- Hashing scheme designed so that hash collisions are rare

Sources of Noise

- Known causes of false positives:
  - pdf to text conversion errors
  - Author or Citations lists
  - Restatement of theorems
  - Review articles, graduate theses
  - Occasional block quotation of text
- Forces us to ignore small overlaps
  - >100 7-grams for authors reusing text from their own articles
  - >20 7-grams for text reuse with and without citation

Geographic Distribution

- How are the serial copiers distributed geographically?
- Determine country of origin of submissions
  - Email domain names of primary submitter stored in article metadata
  - E.g.: .uk, .ca, .fr
- Measure text reuse distribution between countries
  - Ignore countries with few authors and few submissions

    (e.g. Moldova, with only 53 papers)
  - Measure fraction of papers that include significant amounts of copied material for each country

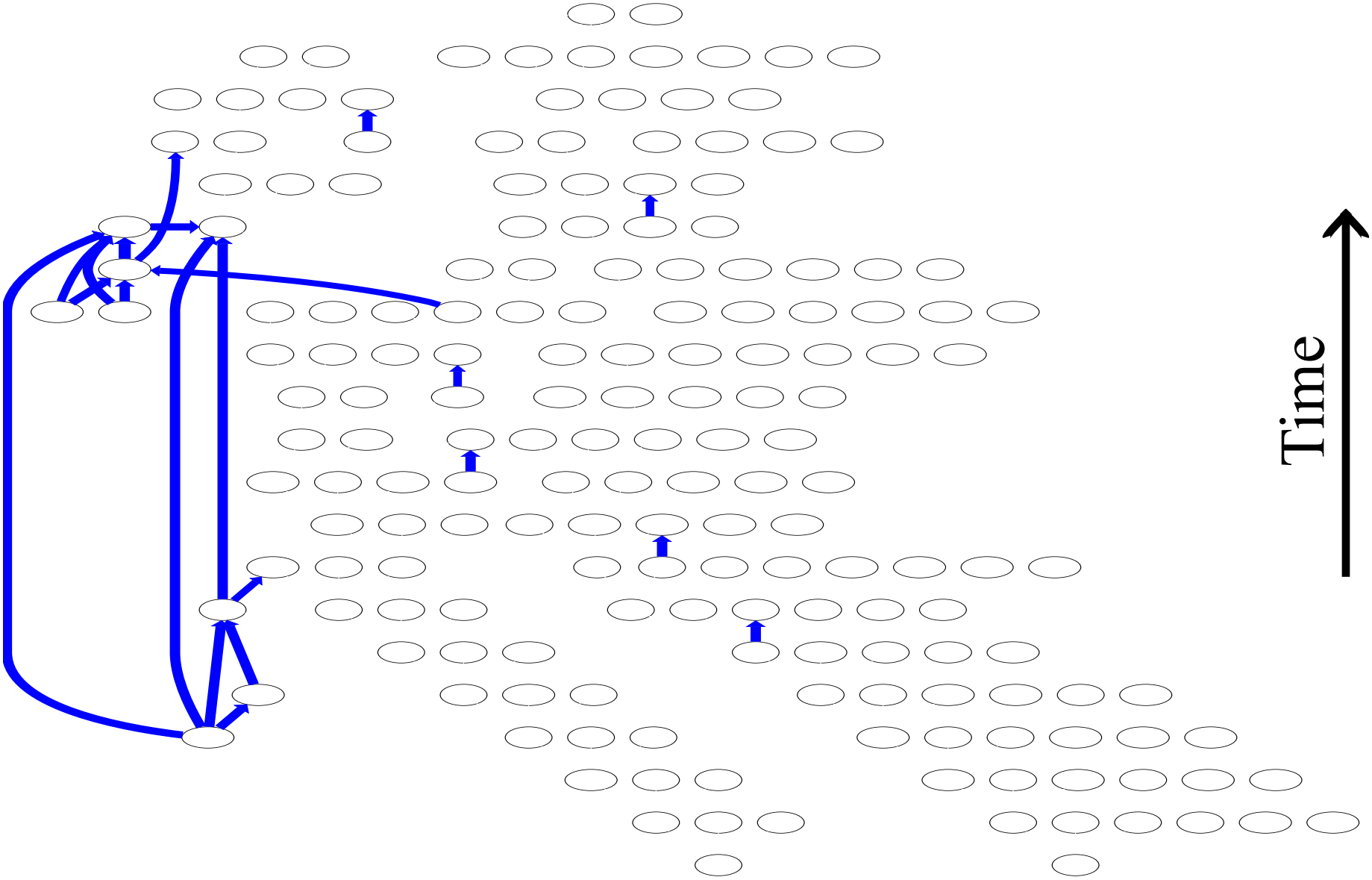
Geographic Distribution

- Habitual copying is not evenly spread between countries
- Examples of countries with highest fraction of papers with significant copied content:
  - Egypt
  - Bulgaria
  - Iran
  - Georgia
  - Belarus
  - Colombia
  - Armenia
  - Greece
- Note that these are all countries were English is not widely spoken as a first language
- Possible that authors from these countries are learning to write in English by mimicking other articles
  - But this does not explain why serial copiers copy from themselves or their colleagues, not from established English-speaking authors
- **Note:** We do not intend to disparage any country's scientific education system or publishing practices: we merely point out that these patterns exist and may be corrected for.

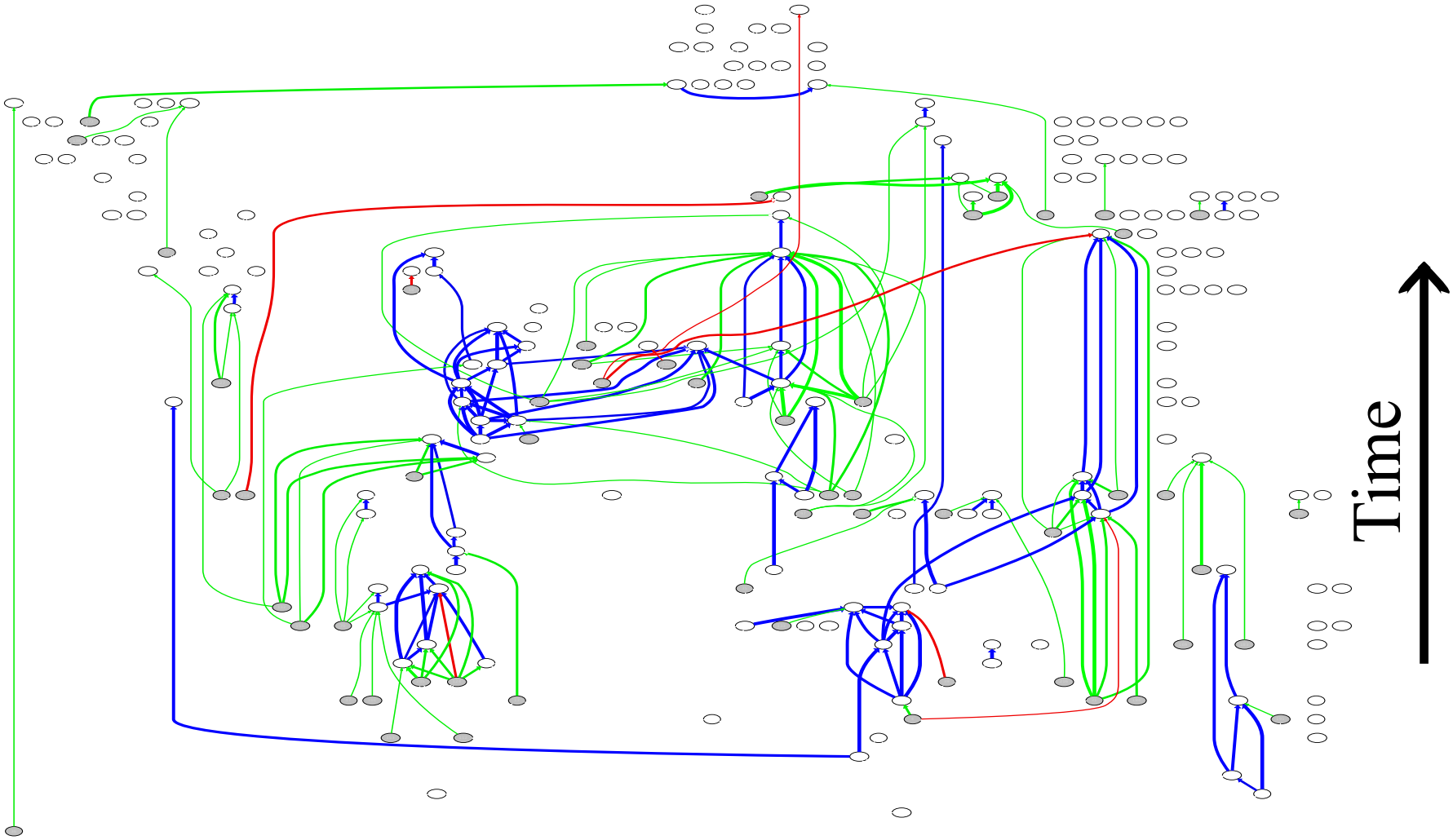
Visualization of Text Overlap using Networks

- Text Overlap Networks
  - Collection of nodes connected by edges
  - Edges represent relationships between the nodes
  - Helpful formalism for parsing large, densely interconnected data sets
- Nodes – represent individual papers by a single author
- Edges – represent text reuse relationship between papers
  - Directed edges – future papers borrow from past papers
  - Colored edges – three modes of text reuse
- Graph visualization:
  - Intuition of text overlap patterns
  - Visualization reveals the existence of serial copiers

Visualization of Text Overlap using Networks- Example 1



Visualization of Text Overlap using Networks – Example 2



- Grey nodes represent papers by other authors that the offending author reused text from
- Note density of edges, as well as presence of Red and Green edges