Network Project
A Growing Network Model

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Abstract: You may want to write a concise abstract that briefly puts the work into context, explains what was done, how it was done, the main results, the conclusions you could draw and the implications.

Word Count: ???? words excluding font page, figure captions, table captions, acknowledgement and bibliography.

0 Introduction

Brief paragraph with your Aims and Objectives. Marked under the "Professional Skills" category.

Definition

Give your definition of the BA model as implemented by you in this work. [**3 marks**]
TOTOTO

1 Phase 1: Pure Preferential Attachment Π_{pa}

1.1 Implementation

1.1.1 Numerical Implementation

Describe how you implemented the BA model numerically. [**3 marks**]

1.1.2 Initial Graph

What type of initial graph do you use and why? [**3 marks**]

1.1.3 Type of Graph

What type of graph do you produce and why? [**3 marks**]

1.1.4 Working Code

How do you know that your programme is working correctly? [**2 marks**]

1.1.5 Parameters

Describe the parameters your programme needs, the values you chose, and why. [**2 marks**]

1.2 Preferential Attachment Degree Distribution Theory

1.2.1 Theoretical Derivation

Give your best theoretical derivation for the form of the degree distribution $p(k)$ in the long-time limit for Preferential Attachment (PA) in the BA model. [**4 marks**]

1.2.2 Theoretical Checks

Check your approximate theoretical solution for $p(k)$ has the correct properties. [**4 marks**]

1.3 Preferential Attachment Degree Distribution Numerics

1.3.1 Fat-Tail

How did you deal with any problems that a fat-tailed distribution causes? [**4 marks**]

1.3.2 Numerical Results

Show how you compared your theoretical result to your numerical data for fixed N but different m. Give a visualisation which shows you whether you have a good or bad fit of your numerical data to your theoretical results. [**4 marks**]

1.3.3 Statistics

Show statistically whether your numerical data fits your theoretical predictions. [**6 marks**]

1.4 Preferential Attachment Largest Degree and Data Collapse

1.4.1 Largest Degree Theory

Give your best theoretical estimate of how the largest expected degree, k_1 (subscript 1 indicating the degree of the vertex ranked first by degree size) depends on the number of vertices N in a finite size system and on m the number of edges added each step. [**4 marks**]

1.4.2 Numerical Results for Largest Degree

Study of the behaviour of k_1 as N is varied for one sensible fixed value of m (justify your choice of parameters). Estimate uncertainties/errors where possible. Compare against your theoretical prediction. [**4 marks**]

1.4.3 Data Collapse

Illustrate the finite size effects by studying a single value of m (justify your choice for m) but varying N and looking for data collapse. You should describe how you tried to use an understanding of the k_1 scale to look for any finite size effects in the tail of the distribution, describing any results found. Further mathematical investigation of finite size effects is not required as it is extremely hard to do. [**4 marks**]

2 Phase 2: Pure Random Attachment Π_{rnd}

2.1 Random Attachment Theoretical Derivations

2.1.1 Degree Distribution Theory

Give your best theoretical derivation for the form of the degree distribution in the long-time limit. Check your approximate theoretical solution has the correct properties. [**4 marks**]

2.1.2 Largest Degree Theory

Give your best theoretical estimate of how the largest expected degree, k_1 depends on the number of vertices N in a finite size system. [**2 marks**]

2.2 Random Attachment Numerical Results

2.2.1 Degree Distribution Numerical Results

Show how you compared your theoretical result to your numerical data for different m at one large value of N. Is your theory a good fit to your data? How did you arrive at your conclusion? [**6 marks**]

2.2.2 Largest Degree Numerical Results

Study of the behaviour of k_1 as N is varied for one sensible fixed value of m (justify your choice of parameters) including estimates of uncertainties on any measurements. Compare against your theoretical prediction. Illustrate the finite size effects by looking for possible data collapse. [**4 marks**]

3 Phase 3: Existing Vertices Model

3.1 Existing Vertices Model Theoretical Derivations

Give your best theoretical derivation for the form of the degree distribution in the long-time limit for the specific scenario given, namely where some edges added run between exiting vertices while the rest are between the new vertex and one existing vertex as before. Check your solution. [**8 marks**]

3.2 Existing Vertices Model Numerical Results

Show how you compared your theoretical result to your numerical data for different m at one large value of N. Is your theory a good fit to your data? How did you arrive at your conclusion? Analyse the finite size effects by looking for possible data collapse. [**8 marks**]

4 Conclusions

Just one or two sentences to round off the report. Marked under the "Professional Skills" category.

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Note: *The Acknowledgement and Bibliography do not count towards the 2500 word limit nor the 16 page limit. An acknowledgement section is not required. For a report of this type and size, references may well not be needed but if you do reference other work, such as a useful book [1] or a useful result [2], a formal bibliography is one way to do this. No formal marks for either of these sections but they could be considered as part of the overall Organisation, Presentation or English marks.*

Acknowledgements

Optional. Not required but you might want to thank A.Demonstrator or A.Friend for help.

References

[1] K.Christensen and N.Maloney, *Complexity and Criticality*, Imperial College Press, London, 2005.

[2] T.S. Evans, *Astounding Paper*, Journal of Amazing Results, **9** (2023) 3134.

Delete text in this box from your final version.

Professional Skills

Do not include this section in your report, it is for your information only

Your report should be

- written in clear comprehensible English [**6 marks**]
- be well presented [**6 marks**]
- well organised and follows brief [**6 marks**]

This is highly subjective but generally most reports score well on these aspects. Many of the problems come from plots which might have: small unreadable fonts used for labels, labels used for variables are different from those in the text (they reflect the naming scheme used in the programme), unexplained equations of some fit with unrealistic accuracy in unexplained coefficients.

[**Total 100 marks**]