Thesis Proposal for MPhil Degree

Student Name	Xiaoyun ZHONG
ID Number	50013978
Group Project	A Metaverse Campus Community
Project Manager	Miaojun HUANG
Project Supervisor	Miaojun HUANG
Individual Project	Multi-AI agent and multi-player perceptual interaction methods and decision-making in Metaverse narrative game
Thesis Supervisor(s)	David Kei Man Yip
Student's Thrust & Hub	CMA Thrust, Info Hub

12/2023
The Hong Kong University of Science and Technology (Guangzhou)

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RBM Research Proposal

Abstract: In the rapidly evolving landscape of technology, the integration of Artificial Intelligence into content generate within the metaverse has become a focal point. However, the current technological faces challenges in optimizing multi-AI agent and multi-player interactions for narrative enrichment. This study explores the intersection of Artificial Intelligence and narrative gaming within the metaverse, conducting a comparative analysis of existing multi-AI agent and multi-player interaction models. We dissects their strengths and weaknesses to propose refinements with a focus on enhancing multi-player interactions and storytelling. The methodological approach involves the development and testing of a specialized AI-Player interactive collaborative decision-making system tailored for narrative metaverse games, with an emphasis on exploring realistic and effective methods for AI-Player interaction and decision-making to elevate game immersion and user experiences in narrative contexts. In the team project, this research provides a comprehensive theoretical framework for addressing the complexities of multi-AI agent and multi-player interactions. Comparative research and experimental findings contribute suggestions and solutions to enhance the AI-Player interactive experience, aligning with the overarching goal of the team project. Furthermore, the development of a collaborative decision-making system for multi-AI agents and multi-player interactions is poised to elevate interactivity and advance the broader scope of AI-driven metaverse games.

Part I Introduction to the Group Project

1.1 Background and Objective

Briefly describe the group project.

1.2 Significance

Explain why this group project is essential in the real-world context.

1.3 Project Composition

Provide information of the individual projects that collectively comprise the group project, including titles/researcher names of each individual project.

1.4 Project Connections

Outline the connections between the group project and the individual projects.

1.5 Project Milestones

List the key milestones at different stages of the group project implementation.

Part II Proposal of the Individual Project

2.1 Significance and Relevance of the Individual Project to the Group Project

Briefly describe the group project.

2.1.1 Complementary Role

Explain how your project complements the broader objectives of the group project. Discuss how your work fills a necessary gap or adds a unique perspective to the collective effort.

2.1.2 Value Addition

Describe the specific ways in which your project adds value to the group project. This might include the development of critical components, providing specialized knowledge or skills, or enhancing the overall quality and scope of the group project.

2.1.3 Interdependence

Highlight any dependencies between your project and other components of the group project. Explain how collaboration and coordination with other group members are integral to achieving both individual and group objectives.

2.2 Statement of the Individual Project in Details

Briefly describe the group project.

2.2.1 Literature/Market Review and Problem Definition

2.2.2 Objective and Scope of the Project

2.2.3 Research Method and Justification

2.2.4 Execution Plan

2.2.5 Intended Outcomes

Outcome 1: Description & relation of this outcome to the group project.

Outcome 2: Description & relation of this outcome to the group project.

Outcome 3: Description & relation of this outcome to the group project.

2.3 Project Milestones

Table the group project and the individual project milestones. Illustrate the relation and alignment of milestones of the individual project and those of the group project.

2.4 Budget Plan

Briefly describe the group project.

2.4.1 Budget Breakdown

Break down the budget into categories.

2.4.2 Cost-Effectiveness

Discuss cost-effectiveness.

2.5 Risk Analysis and Mitigation

Briefly describe the group project.

2.5.1 Potential Risks or Challenges

Identify potential risks or challenges that may arise during implementation of the project.

2.5.2 Impact of the Risks

Assess the impact of the risks to the success of the project and propose mitigation strategies.

3 How to submit to the *Thesis Proposal for Red Bird Mphil*

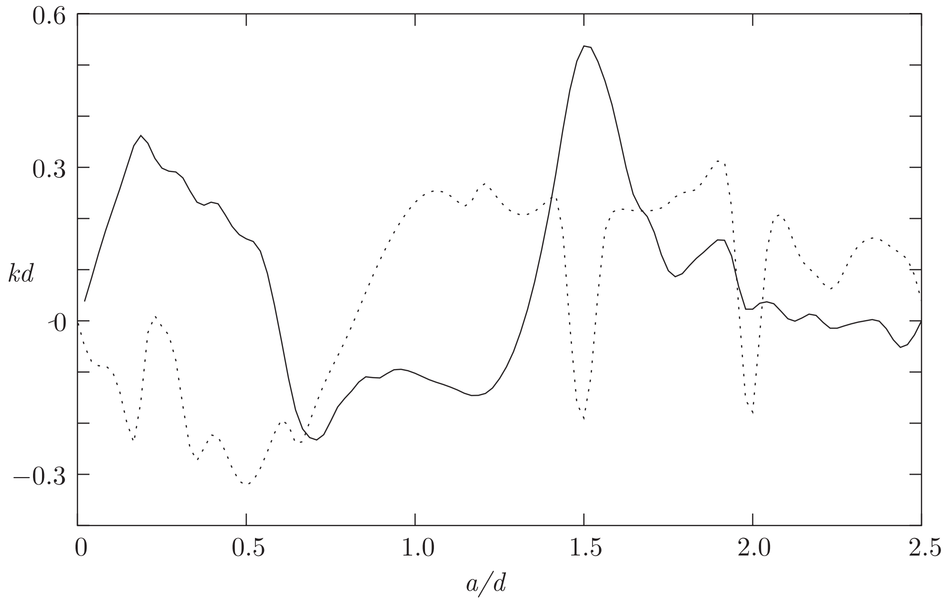
Authors must submit using the online submission and peer review system, ScholarOne Manuscripts (formerly Manuscript Central) at http://mc.manuscriptcentral.com/pla. If visiting the site for the first time, users must create a new account by clicking on 'register here'. Once logged in, authors should click on the 'Corresponding Author Centre', from which point a new manuscript can be submitted, with step-by-step instructions provided. Authors must at this stage specify the type of paper submitted: 'original article' or 'review' (see §**??** for more details). Once your submission is completed you will receive an email confirmation.

4 Figures

Figures should be as small as possible while displaying clearly all the information required, and with all lettering readable. Every effort should be taken to avoid figures that run over more than one page. There is no charge for colour figures. For review purposes figures should be embedded within the manuscript. Upon final acceptance, however, individual figure files will be required for production. These should be submitted in EPS or high-resolution TIFF format (1200 dpi for lines, 300 dpi for halftone, and 600 dpi for a mixture of lines and halftone). The minimum acceptable width of any line is 0.5pt. Each figure should be accompanied by a single caption, to appear beneath, and must be cited in the text. Figures should appear in the order in which they are first mentioned in the text and figure files must be named accordingly to assist the production process (and numbering of figures should continue through any appendices). For example see figures 1 and 2. Failure to follow figure guidelines may result in a request for resupply and a subsequent delay in the production process.

4.1 Tables

Tables, however small, must be numbered sequentially in the order in which they are mentioned in the text. The word *table* is only capitalized at the start of a sentence. See table 2 for an example.



[h]

FIGURE 1. Trapped-mode wavenumbers, kd, plotted against a/d for three ellipses: ——, $b/a = 1$; $\cdots\cdots$, $b/a = 1.5$.

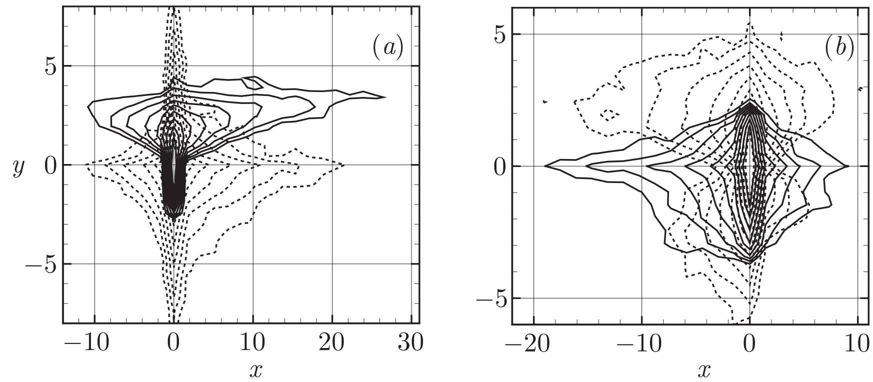


FIGURE 2. The features of the four possible modes corresponding to (*a*) periodic and (*b*) half-periodic solutions.

a/d	$M = 4$	$M = 8$	Callan *et al.*
0.1	1.56905	1.56	1.56904
0.3	1.50484	1.504	1.50484
0.55	1.39128	1.391	1.39131
0.7	1.32281	10.322	1.32288
0.913	1.34479	100.351	1.35185

TABLE 1. Values of kd at which trapped modes occur when $\rho(\theta) = a$

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TABLE 2. Values of kd at which trapped modes occur when $\rho(\theta) = a$

5 Notation and style

Generally any queries concerning notation and journal style can be answered by viewing recent pages in the Journal. However, the following guide provides the key points to note. It is expected that Journal style will be followed, and authors should take care to define all variables or entities upon first use. Also note that footnotes are not normally accepted.

5.1 Mathematical notation

5.1.1 Setting variables, functions, vectors, matrices etc

Italic font should be used for denoting variables, with multiple-letter symbols avoided except in the case of dimensionless numbers.

Upright Roman font (or upright Greek where appropriate) should be used for:

- Operators: sin, log, d, $\mathit{\Delta}$, e etc.
- Constants: i ($\sqrt{-1}$), π (defined as `\upi`), etc.
- Functions: Ai, Bi (Airy functions, defined as `\Ai` and `\Bi`), Re (real part, defined as `\Real`), Im (imaginary part, defined as `\Imag`), etc.
- Physical units: cm, s, etc
- Abbreviations: c.c. (complex conjugate), h.o.t. (higher-order terms), DNS, etc.

Bold italic font (or bold sloping Greek) should be used for:

- Vectors (with the centred dot for a scalar product also in bold): $\boldsymbol{i} \boldsymbol{\cdot} \boldsymbol{j}$

Bold sloping sans serif font, defined by the `\mathsfbi` macro, should be used for:

- Tensors and matrices: $\boldsymbol{\mathsf{D}}$

Script font (for example $\mathcal{G}$, $\mathcal{R}$) can be used as an alternative to italic when the same letter denotes a different quantity (use `mathcal` in LaTeX).

The product symbol ($\times$) should only be used to denote multiplication where an equation is broken over more than one line, to denote a cross product, or between numbers (the $\cdot$ symbol should not be used, except to denote a scalar product specifically).

5.1.2 Other symbols

A centred point should be used only for the scalar product of vectors. Large numbers that are not scientific powers should not include commas, but have the form 1600 or 16 000 or 160 000. Use O to denote 'of the order of', not the LaTeX $\mathcal{O}$.

5.2 Equations

Here are some equations for example.

$$(\nabla^2 + k^2)G_s = (\nabla^2 + k^2)G_a = 0 \tag{5.1}$$

$$-\frac{1}{2\pi}\int_0^\infty \gamma^{-1}[exp(-k\gamma|y-\eta|)+exp(-k\gamma(2d-y-\eta))]\cos k(x-\xi)t\,\mathrm{d}t, \qquad 0<y, \quad \eta<d, \tag{5.2}$$

$$\gamma(t) = \begin{cases} -\mathrm{i}(1-t^2)^{1/2}, & t \leqslant 1 \\ (t^2-1)^{1/2}, & t > 1. \end{cases} \tag{5.3}$$

$$-\frac{1}{2\pi}\int_0^\infty B(t)\frac{\cosh k\gamma(d-y)}{\gamma\sinh k\gamma d}\cos k(x-\xi)t\,\mathrm{d}t$$

$$G = -\frac{1}{4}\mathrm{i}(H_0(kr)+H_0(kr_1)) - \frac{1}{\pi}\int_0^\infty \frac{\mathrm{e}^{-k\gamma d}}{\gamma\sinh k\gamma d}\cosh k\gamma(d-y)\cosh k\gamma(d-\eta) \tag{5.4}$$

Note that when equations are included in definitions, it may be suitable to render them in line, rather than in the equation environment: $\boldsymbol{n}_q = (-y'(\theta), x'(\theta))/w(\theta)$. Now $G_a = \frac{1}{4}Y_0(kr) + \widetilde{G_a}$ where $r = \{[x(\theta)-x(\psi)]^2 + [y(\theta)-y(\psi)]^2\}^{1/2}$ and $\widetilde{G_a}$ is regular as $kr \to 0$. However, any fractions displayed like this, other than $\frac{1}{2}$ or $\frac{1}{4}$, must be written on the line, and not stacked (ie 1/3).

$$\begin{aligned}\frac{\partial}{\partial n_q}\left(\frac{1}{4}Y_0(kr)\right) &\sim \frac{1}{4\pi w^3(\theta)}[x''(\theta)y'(\theta) - y''(\theta)x'(\theta)] \\ &= \frac{1}{4\pi w^3(\theta)}[\rho'(\theta)\rho''(\theta) - \rho^2(\theta) - 2\rho'^2(\theta)] \quad \text{as} \quad kr \to 0.\end{aligned} \tag{5.5}$$

$$\frac{1}{2}\phi_i = \frac{\pi}{M}\sum_{j=1}^{M}\phi_j K_{ij}^a w_j, \qquad i = 1,\,\ldots,\,M, \tag{5.6}$$

where

$$K_{ij}^a = \begin{cases} \partial G_a(\theta_i,\theta_j)/\partial n_q, & i \neq j \\ \partial \widetilde{G_a}(\theta_i,\theta_i)/\partial n_q + [\rho_i'\rho_i'' - \rho_i^2 - 2\rho_i'^2]/4\pi w_i^3, & i = j. \end{cases} \tag{5.7}$$

$$\rho_l = \lim_{\zeta\to Z_l^-(x)} \rho(x,\zeta), \quad \rho_u = \lim_{\zeta\to Z_u^+(x)} \rho(x,\zeta) \tag{5.8a,b}$$

$$(\rho(x,\zeta),\phi_{\zeta\zeta}(x,\zeta)) = (\rho_0, N_0) \quad \text{for} \quad Z_l(x) < \zeta < Z_u(x). \tag{5.9}$$

$$\tau_{ij} = (\overline{\overline{u}_i\overline{u}_j} - \overline{u}_i\overline{u}_j) + (\overline{\overline{u}_i u_j^{SGS} + u_i^{SGS}\overline{u}_j}) + \overline{u_i^{SGS}u_j^{SGS}}, \tag{5.10a}$$

$$\tau_j^\theta = (\overline{\overline{u}_j\overline{\theta}} - \overline{u}_j\overline{\theta}) + (\overline{\overline{u}_j\theta^{SGS} + u_j^{SGS}\overline{\theta}}) + \overline{u_j^{SGS}\theta^{SGS}}. \tag{5.10b}$$

$$\boldsymbol{Q}_C = \begin{bmatrix} -\omega^{-2}V_w' & -(\alpha^t\omega)^{-1} & 0 & 0 & 0 \\ \dfrac{\beta}{\alpha\omega^2}V_w' & 0 & 0 & 0 & \mathrm{i}\omega^{-1} \\ \mathrm{i}\omega^{-1} & 0 & 0 & 0 & 0 \\ \mathrm{i}R_\delta^{-1}(\alpha^t + \omega^{-1}V_w'') & 0 & -(\mathrm{i}\alpha^t R_\delta)^{-1} & 0 & 0 \\ \dfrac{\mathrm{i}\beta}{\alpha\omega}R_\delta^{-1}V_w'' & 0 & 0 & 0 & 0 \\ (\mathrm{i}\alpha^t)^{-1}V_w' & (3R_\delta^{-1} + c^t(\mathrm{i}\alpha^t)^{-1}) & 0 & -(\alpha^t)^{-2}R_\delta^{-1} & 0 \end{bmatrix}. \tag{5.11}$$

$$\boldsymbol{\eta}^t = \hat{\boldsymbol{\eta}}^t \exp[\mathrm{i}(\alpha^t x_1^t - \omega t)], \tag{5.12}$$

where $\hat{\boldsymbol{\eta}}^t = \boldsymbol{b}\exp(\mathrm{i}\gamma x_3^t)$.

$$\mathrm{Det}[\rho\omega^2\delta_{ps} - C_{pqrs}^t k_q^t k_r^t] = 0, \tag{5.13}$$

$$\langle k_1^t, k_2^t, k_3^t\rangle = \langle \alpha^t, 0, \gamma\rangle \tag{5.14}$$

$$\boldsymbol{f}(\theta, \psi) = (g(\psi)\cos\theta, g(\psi)\sin\theta, f(\psi)). \tag{5.15}$$

$$f(\psi_1) = \frac{3b}{\pi[2(a+b\cos\psi_1)]^{3/2}} \int_0^{2\pi} \frac{(\sin\psi_1 - \sin\psi)(a+b\cos\psi)^{1/2}}{[1-\cos(\psi_1-\psi)](2+\alpha)^{1/2}} \mathrm{d}x, \tag{5.16}$$

$$\begin{aligned} g(\psi_1) = {} & \frac{3}{\pi[2(a+b\cos\psi_1)]^{3/2}} \int_0^{2\pi} \left(\frac{a+b\cos\psi}{2+\alpha}\right)^{1/2} \left\{ f(\psi)[(\cos\psi_1 - b\beta_1)S + \beta_1 P] \right. \\ & \times \frac{\sin\psi_1 - \sin\psi}{1-\cos(\psi_1-\psi)} + g(\psi)\left[\left(2+\alpha - \frac{(\sin\psi_1-\sin\psi)^2}{1-\cos(\psi-\psi_1)} - b^2\gamma\right)S \right. \\ & \left.\left. + \left(b^2\cos\psi_1\gamma - \frac{a}{b}\alpha\right) F(\frac{1}{2}\pi, \delta) - (2+\alpha)\cos\psi_1 E(\frac{1}{2}\pi, \delta)\right]\right\} \mathrm{d}\psi, \end{aligned} \tag{5.17}$$

$$\alpha = \alpha(\psi, \psi_1) = \frac{b^2[1-\cos(\psi-\psi_1)]}{(a+b\cos\psi)(a+b\cos\psi_1)}, \quad \beta - \beta(\psi, \psi_1) = \frac{1-\cos(\psi-\psi_1)}{a+b\cos\psi}. \tag{5.18}$$

$$\left.\begin{aligned} & H(0) = \frac{\epsilon\overline{C}_v}{\tilde{v}_T^{1/2}(1-\beta)}, \quad H'(0) = -1 + \epsilon^{2/3}\overline{C}_u + \epsilon\hat{C}_u'; \\ & H''(0) = \frac{\epsilon u_*^2}{\tilde{v}_T^{1/2} u_P^2}, \quad H'(\infty) = 0. \end{aligned}\right\} \tag{5.19}$$

LEMMA 1.

Let $f(z)$ be a trial function defined on $[0,1]$. Let Λ_1 denote the ground-state eigenvalue for $-\mathrm{d}^2g/\mathrm{d}z^2 = \Lambda g$, where g must satisfy $\pm\mathrm{d}g/\mathrm{d}z + \alpha g = 0$ at $z = 0, 1$ for some non-negative constant α. Then for any f that is not identically zero we have

$$\frac{\alpha(f^2(0) + f^2(1)) + \displaystyle\int_0^1 \left(\frac{\mathrm{d}f}{\mathrm{d}z}\right)^2 \mathrm{d}z}{\displaystyle\int_0^1 f^2 \mathrm{d}z} \geqslant \Lambda_1 \geqslant \left(\frac{-\alpha + (\alpha^2 + 8\pi^2\alpha)^{1/2}}{4\pi}\right)^2. \tag{5.20}$$

COROLLARY 1. *Any non-zero trial function f which satisfies the boundary condition $f(0) = f(1) = 0$ always satisfies*

$$\int_0^1 \left(\frac{\mathrm{d}f}{\mathrm{d}z}\right)^2 \mathrm{d}z. \tag{5.21}$$

6 Citations and references

The natbib package can be used to generate citation variations, as shown below. [1]

The References section can either be built from individual `\bibitem` commands, or can be built using BibTex. The BibTex files used to generate the references in this document can be found in the zip file in the Instructions for Contributors section of the JPP website.

Where there are up to ten authors, all authors' names should be given in the reference list. Where there are more than ten authors, only the first name should appear, followed by et al.

Acknowledgements should be included at the end of the paper, before the References section or any appendicies, and should be a separate paragraph without a heading. Several anonymous individuals are thanked for contributions to these instructions.

A

This appendix contains sample equations in the JPP style. Please refer to the LaTeX source file for examples of how to display such equations in your manuscript.

References

[1]I. Ng and K. Zhang, "Towards Federated Bayesian Network Structure Learning with Continuous Optimization," in *Proceedings of The 25th International Conference on Artificial Intelligence and Statistics*, PMLR, May 3, 2022, pp. 8095–8111. [Online]. Available: `https://proceedings.mlr.press/v151/ng22a.html` (visited on 02/06/2023).