A HYBRID APPROACH
ON
ONLINE NOVEL RECOMMENDATION

By Tien Nguyen

Spring 2023-CS 274

INTRODUCTION

- BookCrossing, Amazon, and GoodReads are popular websites that offer assistance with book discovery
- The approach for recommending books is different from the approach for recommending online novels
- Online novel reading platforms have the added benefit of allowing users to read novels on the platforms and keeping track of users' reading progress
- Importance: the system can improve the user's overall reading experience and keep them engaged with the platform
- There is only one paper that has proposed an approach, NovelNet for Online Novel Recommendation [1]

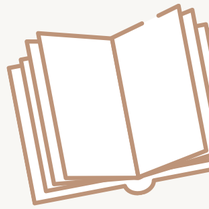
RELATED WORK

- **Book Recommendation:**
  - Putri et al. built a model to incorporate the Convolutional Neural Network (CNN) algorithm for their book recommendation system [2]
- **Repeat Consumption:**
  - Explored in various domains such as music, TV programs, E-commerce, etc
  - Ren et al. introduced a model called RepeatNet, which recommends new and previously consumed items at the same time [3]
- **Session-based recommendation**
  - Its setting is similar to NovelNet's setting [1]

BASELINE- DATA

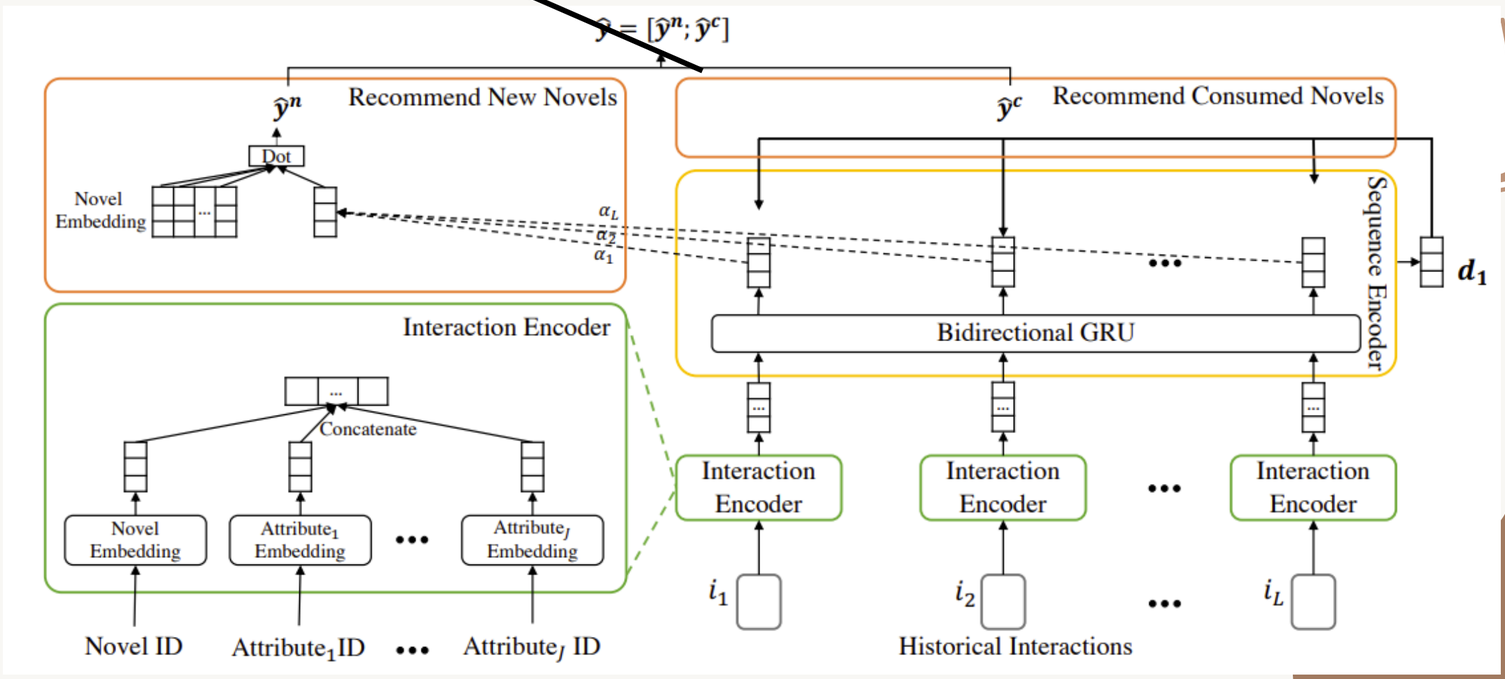
- Was collected from QQ browser.

- Training set has 91,311 users and 18,487 novels.
  Valid set has 34,857 users and 10598 novels.
  Test set has 38,338 users and 10,265 novels.



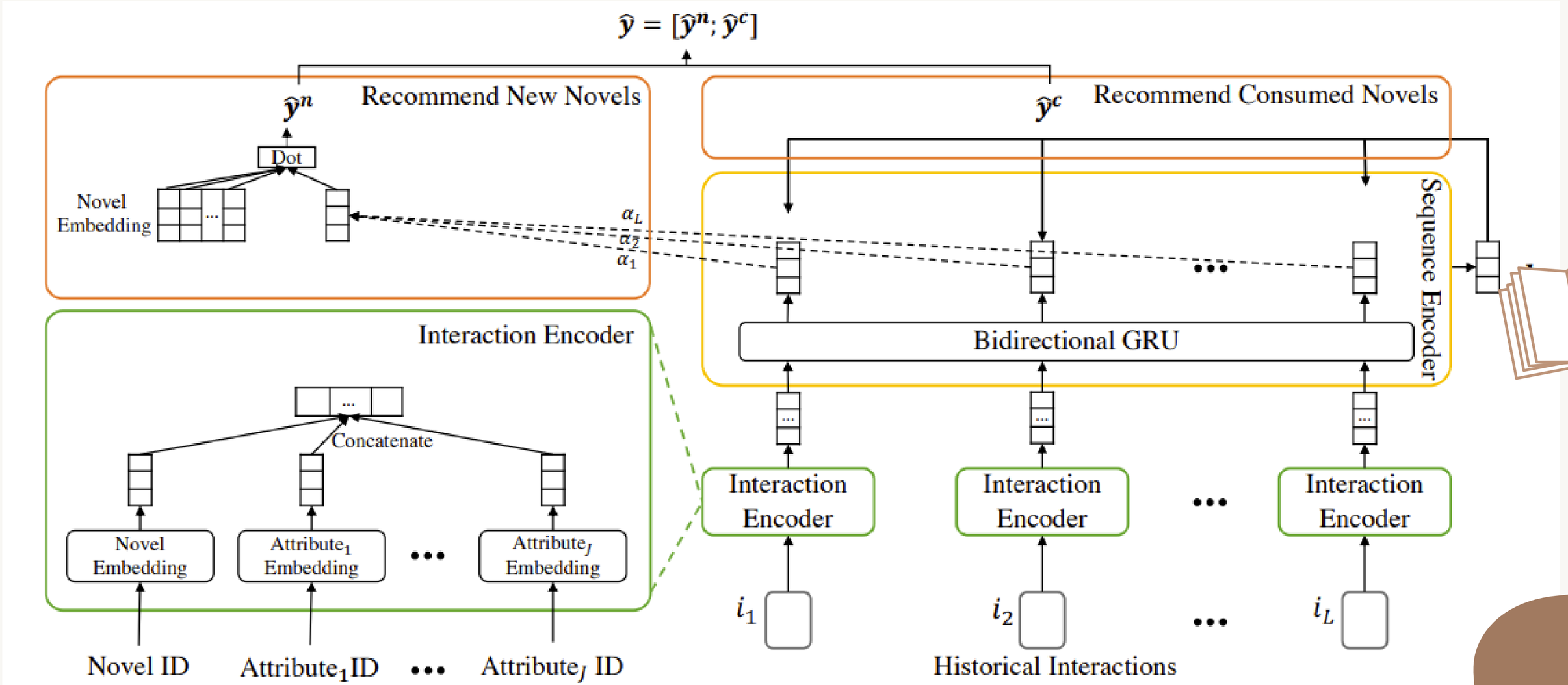
- Several interaction features : novelID, item_intro, item_real_read, item_read_duration,item_count, temporal_gaps, collect, etc

BASELINE- ARCHITECTURE



The architecture of our NovelNet for online novel recommendation [1]

BASELINE- ARCHITECTURE



The architecture of our NovelNet for online novel recommendation [1]

BASELINE- EVALUATION

MRR@k (Mean Reciprocal Rank) : measures the quality of the top k recommendation

$$MRR = \frac{1}{|U_{all}|} \sum_{u=1}^{|U_{all}|} RR(u)$$

$$RR(u) = \sum_{i \leq L} \frac{relevance_i}{rank_i}$$

where $RR(u)$ is the reciprocal rank of a user u, and it is defined by the sum of relevance score of top L items weighted by reciprocal rank. MRR is simply the mean of all users in the test dataset.

Fig 1: MRR formula [6]

Recall@k: measures the ability of the recommendation system to include relevant items in the top-k recommendations

$$Recall@k = \frac{\#\ of\ top\ k\ recommendations\ that\ are\ relevant}{\#\ of\ all\ relevant\ items}$$

BASELINE- REPRODUCTION

	MRR@k				Recall @k		
	@1	@5	@10	@20	@5	@10	@20
NovelNet (Li et al [1])	47.02	51.33	52.00	52.37	58.36	63.43	68.72
NovelNet (Reproduction)	46.35	50.21	50.69	51.09	56.15	59.85	65.53

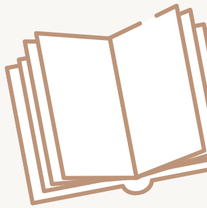
Differences:

- **Original baseline model: 10 epochs, Reproduction model : 3 epochs**
- **The randomness when using Bidirectional GRU**

NEW APPROACH: OBSERVATION 1

- Session-based recommendation model, Sequence and Time Aware Neighborhood (STAN) was used as baselines [1]
- Non-neural-network models offered more precise recommendations compared to other types of neural architectures [4]
- STAN idea [5]: uses a session-based k-nearest neighbors approach
  - Position of an item in the current session,
  - Recency of past sessions relative to the current session, and
  - Position of recommendable items in neighboring sessions

  => provides a more diverse set of recommendations by taking into account the behavior of other users who have similar interests

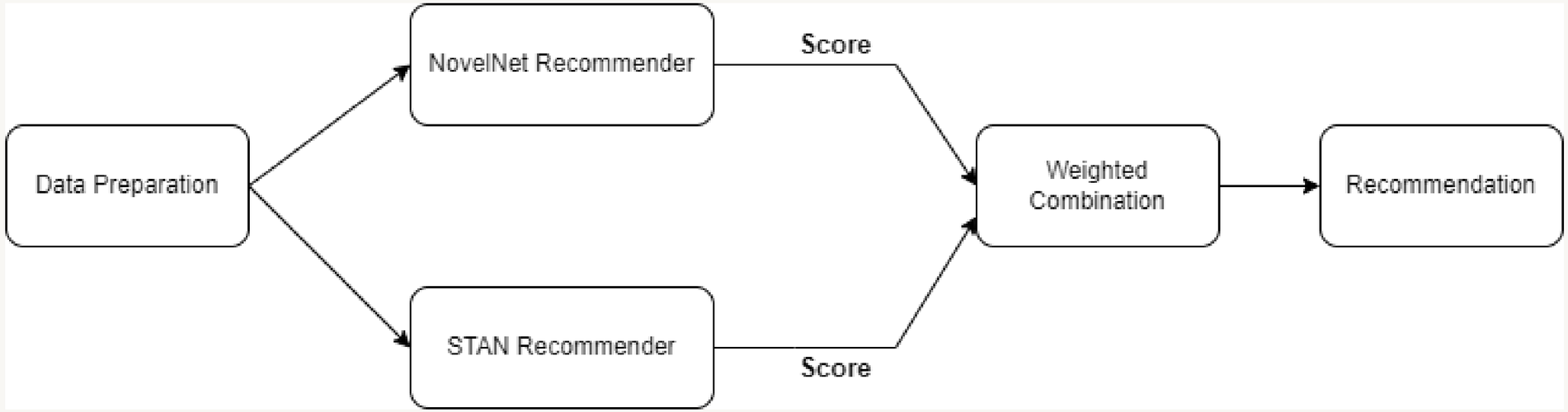


OBSERVATION 2

	Recommendations_NN	Label	Recommendations_Stan
0	[68, 69, 214, 284, 422, 662, 1386, 504, 1106, 2477, 358, 522, 1357, 206, 189, 118, 35, 352, 1233, 609]	[69]	[69, 68, 22381, 9928, 22402, 22401, 22400, 22393, 15357, 13718, 22403, 22376, 10060, 18314, 20250, 20901, 22362, 22361, 21923, 1]
1	[72, 71, 70, 248, 567, 66, 253, 383, 225, 2175, 76, 73, 348, 268, 564, 265, 244, 364, 267, 370]	[73]	[72, 71, 253, 349, 73, 348, 70, 186, 248, 370, 185, 25, 564, 567, 218, 738, 181, 175, 268, 66]
2	[163, 167, 169, 164, 162, 165, 168, 166, 171, 170, 118, 214, 602, 522, 83, 412, 141, 712, 95, 662]	[169]	[164, 162, 163, 165, 306, 36, 609, 358, 206, 1115, 166, 251, 214, 2223, 720, 3856, 662, 3008, 3240, 310]
3	[169, 163, 164, 162, 167, 171, 165, 166, 168, 170, 118, 602, 522, 214, 83, 141, 712, 95, 412, 14]	[167]	[163, 169, 165, 170, 162, 171, 164, 3582, 3436, 12110, 8563, 2969, 2360, 13867, 1976, 609, 168, 3662, 18060, 2167]
4	[200, 214, 456, 243, 274, 260, 201, 2001, 722, 1808, 1830, 269, 219, 952, 953, 184, 650, 1829, 1580, 358]	[200]	[200, 201, 456, 202, 184, 178, 243, 269, 274, 2001, 176, 260, 952, 650, 413, 270, 953, 1830, 1808, 338]
5	[223, 214, 456, 200, 260, 201, 222, 1386, 243, 358, 274, 722, 1808, 202, 2001, 1580, 953, 338, 1830, 219]	[223]	[223, 222, 2076, 2905, 5120, 2299, 649, 3441, 992, 991, 794, 2714, 998, 4266, 2521, 6049, 380, 28769, 3626, 6282]
6	[297, 294, 298, 295, 214, 296, 206, 504, 456, 176, 358, 201, 1829, 25, 260, 274, 1808, 2001, 662, 1580]	[297]	[297, 295, 298, 650, 2306, 176, 178, 200, 1808, 2353, 456, 2113, 294, 1830, 2001, 239, 202, 184, 2179, 296]
7	[127, 351, 214, 456, 353, 201, 260, 352, 243, 358, 274, 354, 1808, 722, 200, 2001, 953, 1386, 952, 1830]	[127]	[127, 352, 351, 241, 353, 354, 197, 201, 207, 720, 736, 8494, 1106, 2315, 581, 126, 25, 358, 214, 5288]
8	[880, 200, 214, 651, 456, 243, 260, 201, 71, 722, 265, 219, 567, 1830, 383, 184, 952, 1808, 274, 2001]	[200]	[200, 880, 274, 456, 184, 178, 201, 269, 243, 2001, 651, 176, 260, 270, 413, 952, 650, 1829, 338, 953]
9	[1001, 71, 218, 214, 456, 243, 567, 383, 260, 248, 274, 201, 2175, 265, 76, 722, 268, 66, 184, 182]	[71]	[71, 1001, 248, 567, 253, 186, 66, 2175, 268, 383, 371, 218, 76, 364, 73, 265, 264, 254, 182, 583]
10	[248, 71, 66, 583, 567, 383, 225, 2175, 76, 268, 73, 265, 255, 564, 348, 267, 364, 254, 414, 244]	[253]	[253, 583, 186, 187, 71, 248, 66, 567, 1237, 73, 383, 268, 76, 348, 2175, 218, 900, 255, 254, 560]
11	[248, 71, 567, 383, 66, 253, 76, 2175, 225, 564, 268, 73, 364, 254, 267, 371, 735, 414, 900, 560]	[348]	[348, 253, 72, 73, 370, 186, 349, 2175, 185, 571, 71, 181, 383, 248, 567, 267, 564, 66, 900, 420]

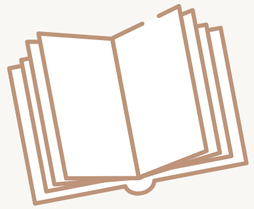
WEIGHTED HYBRID MODEL

- Combining the results of multiple algorithms or models to create a final output
- Each models is assigned a weight
- The models are run on the input data, and their individual outputs are combined using a weighted sum.



WEIGHTED HYBRID MODEL

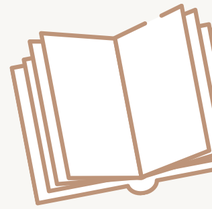
How to choose weight for each model?



- Use the grid search technique to try different weight combinations [[0.1,0.9],[0.25,0.75],[0.5,0.5],[0.75,0.25],[0.9,0.1]]
- Evaluate their performance using metrics such as MRR@K and Recall@k

EXPERIMENT 1

- Ran NovelNet and Stan models separately to get the recommendation lists and scores
- Nomalized scores
- Used several sets of weights to compute the ranking scores.
  [[0.1,0.9],[0.25,0.75],[0.5,0.5],[0.75,0.25],[0.9,0.1]]
- Sorted ranking scores in descending order
- Computed MRR@k and Recall@k where k = 1,5,10,20



RECALL: OBSERVATION 2

	Recommendations_NN	Label	Recommendations_Stan
0	[68, 69, 214, 284, 422, 662, 1386, 504, 1106, 2477, 358, 522, 1357, 206, 189, 118, 35, 352, 1233, 609]	[69]	[69, 68, 22381, 9928, 22402, 22401, 22400, 22393, 15357, 13718, 22403, 22376, 10060, 18314, 20250, 20901, 22362, 22361, 21923, 1]
1	[72, 71, 70, 248, 567, 66, 253, 383, 225, 2175, 76, 73, 348, 268, 564, 265, 244, 364, 267, 370]	[73]	[72, 71, 253, 349, 73, 348, 70, 186, 248, 370, 185, 25, 564, 567, 218, 738, 181, 175, 268, 66]
2	[163, 167, 169, 164, 162, 165, 168, 166, 171, 170, 118, 214, 602, 522, 83, 412, 141, 712, 95, 662]	[169]	[164, 162, 163, 165, 306, 36, 609, 358, 206, 1115, 166, 251, 214, 2223, 720, 3856, 662, 3008, 3240, 310]
3	[169, 163, 164, 162, 167, 171, 165, 166, 168, 170, 118, 602, 522, 214, 83, 141, 712, 95, 412, 14]	[167]	[163, 169, 165, 170, 162, 171, 164, 3582, 3436, 12110, 8563, 2969, 2360, 13867, 1976, 609, 168, 3662, 18060, 2167]
4	[200, 214, 456, 243, 274, 260, 201, 2001, 722, 1808, 1830, 269, 219, 952, 953, 184, 650, 1829, 1580, 358]	[200]	[200, 201, 456, 202, 184, 178, 243, 269, 274, 2001, 176, 260, 952, 650, 413, 270, 953, 1830, 1808, 338]
5	[223, 214, 456, 200, 260, 201, 222, 1386, 243, 358, 274, 722, 1808, 202, 2001, 1580, 953, 338, 1830, 219]	[223]	[223, 222, 2076, 2905, 5120, 2299, 649, 3441, 992, 991, 794, 2714, 998, 4266, 2521, 6049, 380, 28769, 3626, 6282]
6	[297, 294, 298, 295, 214, 296, 206, 504, 456, 176, 358, 201, 1829, 25, 260, 274, 1808, 2001, 662, 1580]	[297]	[297, 295, 298, 650, 2306, 176, 178, 200, 1808, 2353, 456, 2113, 294, 1830, 2001, 239, 202, 184, 2179, 296]
7	[127, 351, 214, 456, 353, 201, 260, 352, 243, 358, 274, 354, 1808, 722, 200, 2001, 953, 1386, 952, 1830]	[127]	[127, 352, 351, 241, 353, 354, 197, 201, 207, 720, 736, 8494, 1106, 2315, 581, 126, 25, 358, 214, 5288]
8	[880, 200, 214, 651, 456, 243, 260, 201, 71, 722, 265, 219, 567, 1830, 383, 184, 952, 1808, 274, 2001]	[200]	[200, 880, 274, 456, 184, 178, 201, 269, 243, 2001, 651, 176, 260, 270, 413, 952, 650, 1829, 338, 953]
9	[1001, 71, 218, 214, 456, 243, 567, 383, 260, 248, 274, 201, 2175, 265, 76, 722, 268, 66, 184, 182]	[71]	[71, 1001, 248, 567, 253, 186, 66, 2175, 268, 383, 371, 218, 76, 364, 73, 265, 264, 254, 182, 583]
10	[248, 71, 66, 583, 567, 383, 225, 2175, 76, 268, 73, 265, 255, 564, 348, 267, 364, 254, 414, 244]	[253]	[253, 583, 186, 187, 71, 248, 66, 567, 1237, 73, 383, 268, 76, 348, 2175, 218, 900, 255, 254, 560]
11	[248, 71, 567, 383, 66, 253, 76, 2175, 225, 564, 268, 73, 364, 254, 267, 371, 735, 414, 900, 560]	[348]	[348, 253, 72, 73, 370, 186, 349, 2175, 185, 571, 71, 181, 383, 248, 567, 267, 564, 66, 900, 420]

RESULTS

0.25 * NovelNet + 0.75 * Stan

	Recommendations	Label
0	[69, 68, 214, 284, 422, 662, 1386, 504, 1106, 2477, 358, 522, 1357, 206, 189, 118, 35, 352, 1233, 609]	[69]
1	[72, 71, 70, 248, 253, 567, 66, 73, 348, 383, 225, 564, 370, 268, 2175, 76, 265, 349, 244, 364]	[73]
2	[164, 162, 163, 167, 169, 165, 168, 166, 171, 170, 306, 214, 36, 609, 662, 358, 206, 1115, 251, 118]	[169]
3	[169, 163, 165, 162, 170, 164, 171, 167, 166, 3582, 3436, 12110, 8563, 2969, 168, 2360, 13867, 1976, 609, 3662]	[167]
4	[200, 201, 456, 214, 243, 274, 184, 260, 269, 2001, 202, 178, 952, 1808, 1830, 650, 953, 722, 219, 176]	[200]
5	[223, 222, 2076, 2905, 5120, 2299, 649, 3441, 992, 991, 794, 2714, 214, 998, 4266, 2521, 6049, 380, 28769, 3626]	[223]
6	[297, 298, 295, 294, 296, 176, 456, 1808, 650, 2306, 178, 200, 214, 2001, 2353, 2113, 1830, 239, 202, 184]	[297]
7	[127, 351, 352, 353, 354, 241, 214, 201, 197, 358, 456, 260, 243, 274, 1808, 207, 720, 736, 722, 200]	[127]
8	[200, 880, 274, 456, 651, 201, 243, 214, 184, 2001, 260, 178, 269, 952, 71, 176, 722, 265, 219, 567]	[200]
9	[71, 1001, 218, 248, 567, 66, 2175, 253, 186, 383, 268, 76, 265, 182, 371, 364, 214, 73, 264, 254]	[71]
10	[253, 583, 248, 71, 66, 567, 383, 2175, 186, 268, 76, 225, 73, 255, 348, 254, 265, 564, 267, 364]	[253]
11	[348, 248, 253, 71, 567, 383, 66, 73, 2175, 76, 564, 225, 267, 900, 268, 364, 72, 254, 371, 735]	[348]

RESULTS

0.75 * NovelNet + 0.25 * Stan

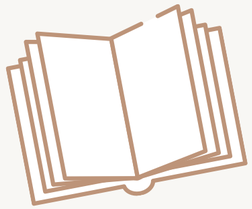
	Recommendations	Label
0	[69, 68, 214, 284, 422, 662, 1386, 504, 1106, 2477, 358, 522, 1357, 206, 189, 118, 35, 352, 1233, 609]	[69]
1	[72, 71, 70, 248, 567, 66, 253, 383, 225, 73, 2175, 348, 76, 268, 564, 265, 244, 364, 370, 267]	[73]
2	[164, 163, 167, 162, 169, 165, 168, 166, 171, 170, 118, 214, 602, 522, 83, 662, 412, 141, 712, 95]	[169]
3	[169, 163, 164, 162, 165, 167, 171, 166, 170, 168, 3582, 3436, 12110, 8563, 2969, 118, 2360, 13867, 602, 522]	[167]
4	[200, 214, 456, 201, 243, 274, 260, 2001, 269, 1808, 184, 722, 1830, 952, 953, 219, 650, 1829, 1580, 358]	[200]
5	[223, 214, 222, 456, 2076, 200, 260, 201, 1386, 243, 2905, 358, 5120, 2299, 274, 722, 1808, 202, 2001, 1580]	[223]
6	[297, 294, 298, 295, 296, 214, 176, 456, 206, 504, 1808, 358, 201, 2001, 1829, 25, 260, 274, 662, 1580]	[297]
7	[127, 351, 214, 352, 353, 456, 354, 201, 260, 243, 358, 274, 1808, 722, 200, 2001, 953, 1386, 952, 1830]	[127]
8	[200, 880, 214, 651, 456, 274, 243, 201, 260, 71, 184, 722, 2001, 265, 952, 219, 567, 1830, 383, 1808]	[200]
9	[71, 1001, 218, 214, 248, 456, 567, 243, 383, 2175, 66, 268, 76, 265, 260, 274, 182, 201, 722, 184]	[71]
10	[583, 253, 248, 71, 66, 567, 383, 225, 2175, 76, 268, 73, 265, 255, 564, 348, 254, 267, 364, 414]	[253]
11	[348, 248, 71, 567, 383, 253, 66, 76, 2175, 225, 73, 564, 268, 364, 267, 254, 371, 735, 414, 900]	[348]

RESULTS

	MRR@k				Recall @k		
	@1	@5	@10	@20	@5	@10	@20
1.0*NovelNet	**46.35**	**50.21**	**50.69**	**51.09**	56.15	59.85	65.53
1.0*Stan	43.01	48.65	49.32	49.67	57.50	62.55	67.56
0.9*NovelNet+0.1*Stan	46.18	50.21	50.68	51.07	56.36	60.6	65.57
0.75*NovelNet+0.25*Stan	45.91	50.13	50.63	51.01	56.52	60.35	65.58
0.5*NovelNet+0.5*Stan	44.74	49.62	50.17	50.53	56.85	61.09	66.07
0.25*NovelNet+0.75*Stan	43.62	49.21	49.81	50.14	57.46	62.0	66.77
0.1*NovelNet+0.9*Stan	43.2	49.1	49.71	50.1	**58.4**	**62.6**	**68.23**

EXPERIMENT 2

What if we try to combine NovelNet with Association Rule model



- **Association Rules (AR) algorithm identifies how frequently two events occur together, such as "users who read... also read".**
- **Determine the significance of the rules by counting the number of times items i and j are found together in any user's session, allowing the algorithm to learn and identify important associations between these items [7].**

RESULTS

Before 2nd hybrid model

	Recommendations_NN	label	Recommendations_Ar
0	[128, 129, 265, 66, 71, 567, 248, 383, 25, 808, 504, 255, 268, 468, 358, 371, 206, 348, 225, 267]	[128]	[128, 129, 22376, 22401, 22400, 22393, 15357, 22381, 13718, 10060, 22355, 18314, 20250, 20901, 22362, 22361, 22356, 22402, 1, 21923]
1	[197, 214, 198, 456, 201, 243, 274, 260, 269, 358, 184, 200, 176, 1829, 722, 1808, 178, 952, 2001, 219]	[197]	[197, 176, 555, 33059, 127, 47745, 338, 662, 214, 4055, 260, 788, 537, 25, 380, 47080, 5399, 254, 23964, 2847]
2	[223, 214, 456, 200, 260, 201, 222, 1386, 243, 358, 274, 722, 1808, 202, 2001, 1580, 953, 338, 1830, 219]	[223]	[223, 5120, 2076, 178, 222, 40776, 2276, 1630, 2671, 129, 10001, 35973, 579, 200, 4266, 28769, 28768, 791, 380, 3191]
3	[856, 201, 1136, 1137, 1138, 214, 456, 455, 260, 243, 358, 200, 1808, 274, 269, 176, 206, 722, 2001, 953]	[1138]	[1138, 184, 200, 201, 456, 2129, 5916, 1829, 269, 260, 1864, 856, 915, 2001, 2113, 2306, 1157, 1140, 214, 1827]
4	[164, 169, 162, 163, 167, 166, 165, 168, 171, 170, 118, 214, 602, 522, 83, 412, 712, 141, 95, 662]	[164]	[162, 3856, 609, 129, 376, 3128, 19339, 7087, 6866, 1449, 1484, 23293, 166, 2701, 3947, 380, 660, 296, 164, 2595]
5	[199, 214, 456, 358, 1386, 201, 662, 422, 260, 243, 206, 504, 352, 338, 274, 176, 1233, 202, 1808, 1580]	[199]	[7254, 199, 206, 1005, 2863, 21265, 914, 25, 1754, 865, 8126, 3016, 1086, 1972, 827, 2286, 34220, 2839, 866, 358]
6	[2662, 72, 244, 25, 214, 71, 567, 946, 383, 243, 456, 2175, 265, 66, 248, 268, 76, 264, 182, 260]	[244]	[244, 370, 71, 567, 76, 2175, 253, 66, 3589, 248, 268, 383, 129, 25, 364, 900, 358, 371, 73, 255]
7	[370, 73, 248, 71, 66, 567, 383, 2175, 76, 348, 225, 253, 268, 460, 900, 265, 255, 564, 583, 264]	[73]	[73, 71, 253, 567, 66, 255, 248, 268, 414, 383, 184, 348, 2175, 182, 264, 371, 370, 254, 76, 908]
8	[269, 504, 456, 214, 243, 260, 201, 71, 184, 274, 265, 200, 567, 722, 248, 383, 1808, 1830, 66, 952]	[504]	[504, 9, 247, 888, 908, 218, 4132, 1822, 1580, 3178, 5381, 798, 4047, 278, 363, 1208, 933, 2349, 642, 475]
9	[9203, 9206, 9204, 1386, 793, 933, 1868, 2227, 78, 214, 1100, 4831, 2079, 9205, 1574, 206, 118, 504, 662, 176]	[6402]	[6402, 1100, 114, 1868, 3178, 5056, 22070, 6378, 66, 7230, 3882, 805, 2079, 1577, 803, 7805, 10760, 9415, 3953, 347]
10	[4172, 5371, 16012, 12415, 1631, 650, 13246, 14275, 3391, 7848, 118, 2193, 206, 239, 602, 16010, 468, 712, 83, 1172]	[5373]	[5373, 5459, 4172, 5461, 17264, 590, 9810, 18220, 5300, 18365, 463, 1095, 660, 14867, 1106, 5452, 6293, 204, 674, 2525]
11	[10992, 1344, 391, 648, 908, 5161, 1842, 387, 8400, 187, 1643, 12217, 10993, 1333, 383, 231, 214, 6281, 1386, 206]	[4027]	[4027, 2902, 10992, 21978, 3256, 1353, 7261, 5795, 2349, 11017, 13143, 1319, 6709, 34079, 10873, 236, 1807, 2944, 23480, 8152]
12	[167, 169, 164, 162, 163, 165, 166, 171, 168, 170, 118, 602, 522, 83, 712, 214, 412, 141, 95, 136]	[163]	[167, 162, 164, 169, 163, 165, 170, 168, 166, 22393, 15357, 22381, 13718, 22376, 10060, 1, 22401, 18314, 20250, 20901]
13	[248, 253, 291, 383, 225, 71, 564, 567, 66, 186, 72, 73, 268, 76, 267, 181, 735, 187, 348, 900]	[225]	[291, 175, 895, 423, 1883, 196, 213, 248, 71, 567, 8080, 2317, 66, 268, 76, 371, 2175, 383, 573, 946]
14	[670, 296, 660, 653, 654, 14, 408, 269, 669, 664, 667, 659, 663, 668, 661, 666, 118, 655, 665, 602]	[653]	[670, 25, 351, 352, 669, 3464, 12183, 5592, 2210, 3721, 6458, 14, 468, 1028, 13619, 2788, 1410, 1962, 14244, 4576]

RESULTS

After 2nd hybrid model

0.75 * NovelNet + 0.25 * AR

	Recommendations	label
0	[128, 129, 265, 66, 71, 567, 248, 383, 25, 808, 504, 255, 268, 468, 358, 371, 206, 348, 225, 267]	[128]
1	[197, 214, 198, 456, 176, 260, 201, 243, 274, 269, 358, 184, 200, 1829, 722, 1808, 178, 952, 2001, 219]	[197]
2	[223, 5120, 2076, 214, 222, 178, 40776, 2276, 1630, 200, 2671, 129, 10001, 35973, 579, 456, 4266, 28769, 28768, 260]	[223]
3	[856, 201, 1138, 1136, 184, 200, 456, 1137, 214, 260, 269, 455, 2001, 2129, 243, 5916, 358, 1808, 274, 1829]	[1138]
4	[162 164, 169, 163, 167, 166, 165, 168, 171, 3856, 609, 129, 170, 376, 3128, 19339, 7087, 6866, 1449, 1484]	[164]
5	[199, 7254, 206, 214, 1005, 2863, 21265, 914, 25, 1754, 865, 8126, 3016, 1086, 1972, 827, 358, 456, 2286, 34220]	[199]
6	[244, 2662, 72, 25, 71, 567, 76, 2175, 370, 66, 383, 248, 268, 214, 253, 946, 3589, 243, 456, 265]	[244]
7	[73, 370, 71, 248, 66, 567, 383, 253, 2175, 348, 255, 76, 268, 225, 264, 460, 900, 265, 564, 583]	[73]
8	[269, 504 456, 214, 243, 260, 201, 71, 184, 274, 265, 200, 567, 722, 248, 383, 1808, 1830, 66, 952]	[504]
9	[9203, 9206, 9204, 6402, 1100, 114, 1868, 3178, 5056, 22070, 6378, 2079, 1386, 66, 7230, 3882, 805, 1577, 803, 7805]	[6402]
10	[4172, 5371, 16012, 12415, 5373, 5459, 1631, 650, 13246, 14275, 5461, 3391, 7848, 118, 2193, 206, 239, 602, 16010, 468]	[5373]
11	[10992, 1344, 391, 648, 908 4027, 5161, 2902, 1842, 387, 8400, 187, 1643, 21978, 3256, 12217, 10993, 1333, 1353, 7261]	[4027]
12	[167, 169, 162, 164, 163, 165, 166, 171, 168, 170, 118, 602, 522, 83, 712, 214, 412, 141, 95, 136]	[163]
13	[291, 248, 253, 383, 71 225 567, 66, 564, 186, 268, 72, 73, 175, 76, 267, 181, 895, 735, 187]	[225]
14	[670, 296, 14, 660, 653, 654, 25, 408, 669, 269, 351, 352, 664, 667, 3464, 659, 12183, 5592, 663, 2210]	[653]

RESULTS

	MRR@k				Recall @k		
	@1	@5	@10	@20	@5	@10	@20
1.0*NovelNet	**46.35**	**50.21**	**50.69**	**51.09**	56.15	59.85	65.53
1.0*AR	40.45	43.24	43.7	44.07	48.1	51.66	56.95
0.9*NovelNet+0.1*AR	46.17	50.14	50.65	51.04	**56.23**	**60.2**	**65.76**
0.75*NovelNet+0.25*AR	45.91	50.0	50.55	50.94	56.23	60.49	66.06
0.5*NovelNet+0.5*AR	45.31	49.56	50.13	50.51	55.97	60.37	65.87
0.25*NovelNet+0.75*AR	44.09	48.31	48.89	49.24	54.94	59.28	64.25
0.1*NovelNet+0.9*AR	42.11	45.89	46.46	46.85	52.42	56.69	62.27

DICUSSION

- NovelNet takes novel_id and interaction features as input
  STAN or AR only take novel_id as input
- NovelNet is better at ranking relevant novels at higher positions than STAN or AR since NovelNet uses bidirectional GRU to capture the user interaction sequence
- STAN is better than AR or NovelNet in term of Recall @k because STAN takes into account the behavior of other users who have similar interests
- When the weight for NovelNet increases (from 0.1 to 0.9), the MRR@k increases since NovelNet itself has highest MRR@k

DICUSSION

- NovelNet + Stan model has high scores than NovelNet + Ar model
- We want relevant novels to have a higher rank
- Give more weight to NovelNet such as 0.9*NN + 0.1*STAN

CONCLUSION & FUTURE WORK

- While the hybrid model is better at recommending all relevant items, it needs improvement in terms of ranking them higher in the list.
- To balance the MRR@k and Recall@K, give more weight to NovelNet
- Need to run Novelet with 10 epochs or more to rank the target label higher in the list.
- Try other hybrid approaches such as switching or cascade
- Try to combine different models

References

[1] Yuncong Li, Cunxiang Yin, Yancheng He, Guoqiang Xu, Jing Cai, Leeven Luo, Sheng-hua Zhong: Modeling User Repeat Consumption Behavior for Online Novel Recommendation. RecSys 2022: 14-24

[2] A. Putri, Z. K. Abdurahman Baizal and D. Rischasdy, "Book Recommender System using Convolutional Neural Network," 2022 International Conference on Advanced Creative Networks and Intelligent Systems (ICACNIS), Bandung, Indonesia, 2022, pp. 1-6, doi: 10.1109/ICACNIS57039.2022.10055753.

[3] Pengjie Ren, Zhumin Chen, Jing Li, Zhaochun Ren, Jun Ma, and Maarten De Rijke. 2019. Repeatnet: A repeat aware neural recommendation machine for session-based recommendation. In Proceedings of the AAAI Conference on Artificial Intelligence, Vol. 33. 4806–4813

[4] Malte Ludewig, Noemi Mauro, Sara Latifi, and Dietmar Jannach. 2021. Empirical analysis of session-based recommendation algorithms. User Modeling and User-Adapted Interaction 31, 1 (2021), 149–181.

[5] Diksha Garg, Priyanka Gupta, Pankaj Malhotra, Lovekesh Vig, and Gautam Shroff. 2019. Sequence and time-aware neighborhood for session-based recommendations: Stan. In Proceedings of the 42nd International ACM SIGIR Conference on Research and Development in Information Retrieval. 1069–1072.

[6] https://towardsdatascience.com/ranking-evaluation-metrics-for-recommender-systems-263d0a66ef54

[7] Malte Ludewig and Dietmar Jannach. Evaluation of session-based recommendation algorithms. User-Modeling and User-Adapted Interaction, 28(4–5):331–390, 2018.

THANK YOU