analysis for lai et al.

2023-12-22

In this document, we run the reliance framework analysis for deception detection task and its corresponding explanations in Lai et al. We estimate the behavioral agents' joint behavioral $\pi(\theta, v, a^b)$ by the empirical distribution in the experiment data. We first show the results using approximation of rational benchmark and the mis-reliant rational benchmark with overfitting to the empirical distribution and then show the results using approximation with the discretized signals.

```
con <- file('./label.json', "r")
raw_data <- ldply(fromJSON(con), data.frame)
raw_data = raw_data %>% group_by(review_text) %>% mutate(review_id = cur_group_id())
human_predictions = raw_data %>% filter(experiment == "control" | experiment == "highlight" |
                                          experiment == "heatmap" | experiment == "examples")
exp_data = raw_data %>% filter(experiment != "control" & experiment != "highlight" &
                                          experiment != "heatmap" & experiment != "examples")
human_predictions = human_predictions %>%
  select(-predicted_label) %>%
  left_join(exp_data %>%
              select(predicted_label, review_text) %>%
              distinct(), by = c("review_text")) %>%
  mutate(predicted_label = as.numeric(predicted_label))
```

```
scoring_rule = function(action, state) {
  (action == state)
}
```

```
task_data = raw_data %>% group_by(review_text) %>% summarise(review_id = cur_group_id())
corpus = tm::Corpus(tm::VectorSource(task_data$review_text))
corpus.cleaned <- tm::tm_map(corpus, tm::removeWords, tm::stopwords('english')) # Removing stop-words
```

```
## Warning in tm_map.SimpleCorpus(corpus, tm::removeWords,
## tm::stopwords("english")): transformation drops documents
```

```
corpus.cleaned <- tm::tm_map(corpus, tm::stemDocument, language = "english") # Stemming the words
```

```
## Warning in tm_map.SimpleCorpus(corpus, tm::stemDocument, language = "english"):
## transformation drops documents
```

```
corpus.cleaned <- tm::tm_map(corpus.cleaned, tm::stripWhitespace) # Trimming excessive whitespaces
```

```
## Warning in tm_map.SimpleCorpus(corpus.cleaned, tm::stripWhitespace):
## transformation drops documents
```

```
tdm <- tm::DocumentTermMatrix(corpus.cleaned)
tdm.tfidf <- tm::weightTfIdf(tdm)
tdm.tfidf <- tm::removeSparseTerms(tdm.tfidf, 0.99)
tfidf.matrix <- as.matrix(tdm.tfidf)
```

```
predict.kmeans <- function(object, newdata){
  centers <- object$centers
```

```
  n_centers <- nrow(centers)
  dist_mat <- as.matrix(dist(rbind(centers, newdata)))
  dist_mat <- dist_mat[-seq(n_centers), seq(n_centers)]
  list(cluster = max.col(-dist_mat), total_error = sum(apply(dist_mat, 1, function(x) min(x))))
}

number_of_partition = 10
partition_size = nrow(tfidf.matrix) / number_of_partition
best.K = -1
best.benchmark = c()
best.test_sd = Inf
for (K in seq(10, 200, 10)) {
  benchmark = c()
  for (i in seq(1, nrow(tfidf.matrix), partition_size)) {
    test_set = tfidf.matrix[i:min(i + partition_size - 1, nrow(tfidf.matrix)),]
    training_set = tfidf.matrix[-(i:min(i + partition_size - 1, nrow(tfidf.matrix))),]
    clustering.kmeans <- kmeans(training_set, K)
    cluster_number = predict(clustering.kmeans, test_set)$cluster
    test_questionId = task_data$review_id[i:min(i + partition_size - 1, nrow(tfidf.matrix))]

    test_task_data = task_data %>% filter(review_id %in% test_questionId) %>% mutate(cluster = cluster_
    test_human_predictions = human_predictions %>%
      filter(review_id %in% test_questionId) %>%
      left_join(test_task_data %>% select(review_id, cluster), by = c("review_id"))

    train_task_data = task_data %>% filter(!(review_id %in% test_questionId)) %>% mutate(cluster = clus
    train_human_predictions = human_predictions %>%
      filter(!(review_id %in% test_questionId)) %>%
      left_join(train_task_data %>% select(review_id, cluster), by = c("review_id"))

    test_rational_action = train_human_predictions %>%
      rbind(test_human_predictions) %>%
      group_by(user_label, predicted_label, cluster) %>%
      mutate(pos_human_payoff = scoring_rule(user_label, actual_label),
             pos_ai_payoff = scoring_rule(predicted_label, actual_label)) %>%
      summarise(pos_human_payoff = mean(pos_human_payoff),
                pos_ai_payoff = mean(pos_ai_payoff))
    benchmark = c(benchmark, (test_human_predictions %>%
      ungroup() %>%
      left_join(test_rational_action, by = c("user_label", "predicted_label", "cluster")) %>%
      mutate(benchmark_action = ifelse(pos_human_payoff > pos_ai_payoff, user_label, predicted_label)) 
      mutate(benchmark = scoring_rule(benchmark_action, actual_label)) %>%
      summarise(benchmark = mean(benchmark)))$benchmark)
  }
  if (best.test_sd > sd(benchmark)) {
    best.test_sd = sd(benchmark)
    best.benchmark = benchmark
    best.K = K
  }
}
```

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```

```
best.K
```

```
## [1] 50
```

```
clustering.kmeans <- kmeans(tfidf.matrix, best.K)
task_data = task_data %>% mutate(cluster = clustering.kmeans$cluster)
```

```
raw_data = raw_data %>% left_join(task_data, by = c("review_text", "review_id"))
human_predictions = raw_data %>% filter(experiment == "control" | experiment == "highlight" |
                                          experiment == "heatmap" | experiment == "examples")
exp_data = raw_data %>% filter(experiment != "control" & experiment != "highlight" &
                                          experiment != "heatmap" & experiment != "examples")
human_predictions = human_predictions %>%
  select(-predicted_label) %>%
  left_join(exp_data %>%
              select(predicted_label, review_text) %>%
              distinct(), by = c("review_text")) %>%
  mutate(predicted_label = as.numeric(predicted_label))
exp_data = exp_data %>%
  left_join(human_predictions %>%
              select(human_pred = user_label, review_text),
            by = c("review_text")) %>%
  mutate(predicted_label = as.numeric(predicted_label))
```

```
## Warning in left_join(., human_predictions %>% select(human_pred = user_label, : Detected an unexpect
## i Row 1 of `x` matches multiple rows in `y`.
## i Row 226 of `y` matches multiple rows in `x`.
## i If a many-to-many relationship is expected, set `relationship =
##   "many-to-many"` to silence this warning.
```

Approximating by overfitting to the empirical distribution

```
rational_action = human_predictions %>%
  group_by(user_label, predicted_label, review_text) %>%
  mutate(pos_human_payoff = scoring_rule(user_label, actual_label),
```

```
        pos_ai_payoff = scoring_rule(predicted_label, actual_label)) %>%
  summarise(pos_human_payoff = mean(pos_human_payoff),
            pos_ai_payoff = mean(pos_ai_payoff))
```

```
## `summarise()` has grouped output by 'user_label', 'predicted_label'. You can
## override using the `.groups` argument.
```

```
rational_data = human_predictions %>%
  ungroup() %>%
  mutate(prior_human_payoff = mean(scoring_rule(user_label, actual_label)),
         prior_ai_payoff = mean(scoring_rule(predicted_label, actual_label))) %>%
  mutate(baseline_action = ifelse(prior_human_payoff > prior_ai_payoff, user_label, predicted_label)) %>
  mutate(baseline = scoring_rule(baseline_action, actual_label)) %>%
  mutate(baseline2_action = ifelse(prior_human_payoff <= prior_ai_payoff, user_label, predicted_label))
  mutate(baseline2 = scoring_rule(baseline2_action, actual_label)) %>%
  left_join(rational_action) %>%
  mutate(benchmark_action = ifelse(pos_human_payoff > pos_ai_payoff, user_label, predicted_label)) %>%
  mutate(benchmark = scoring_rule(benchmark_action, actual_label)) %>%
  mutate(rational_reliance_level = (benchmark_action == predicted_label) & (user_label != predicted_labe
```

```
## Joining with `by = join_by(user_label, review_text, predicted_label)`
```

```
rational_data
```

```
## # A tibble: 6,400 x 24
##    anonymized_worker_id experiment total_time_in_minutes user_label actual_label
##    <chr>                <chr>                      <dbl>      <dbl>        <dbl>
##  1 5AB84043BCE99        control                       10          0            0
##  2 5AB84043BCE99        control                       10          1            0
##  3 5AB84043BCE99        control                       10          1            0
##  4 5AB84043BCE99        control                       10          1            0
##  5 5AB84043BCE99        control                       10          1            0
##  6 5AB84043BCE99        control                       10          1            1
##  7 5AB84043BCE99        control                       10          0            1
##  8 5AB84043BCE99        control                       10          0            1
##  9 5AB84043BCE99        control                       10          0            1
## 10 5AB84043BCE99        control                       10          0            1
## # i 6,390 more rows
## # i 19 more variables: review_time_in_seconds <chr>, review_num <dbl>,
## #   deceptive <dbl>, positive <dbl>, review_text <chr>, review_id <int>,
## #   cluster <int>, predicted_label <dbl>, prior_human_payoff <dbl>,
## #   prior_ai_payoff <dbl>, baseline_action <dbl>, baseline <lgl>,
## #   baseline2_action <dbl>, baseline2 <lgl>, pos_human_payoff <dbl>,
## #   pos_ai_payoff <dbl>, benchmark_action <dbl>, benchmark <lgl>, ...
```

```
sample_size = 40
n_round = 1000
rational_results = data.frame()
for (i in 1:n_round) {
  rational_results = rational_data %>%
    group_by(review_num) %>%
    sample_n(sample_size) %>%
    ungroup() %>%
    summarise(baseline = mean(baseline),
              baseline2 = mean(baseline2),
              benchmark = mean(benchmark),
```

```
            rational_reliance = mean(rational_reliance_level)) %>%
    rbind(rational_results)
}
rational_results = rational_results %>%
  cross_join(exp_data %>% group_by(experiment) %>% summarise())
rational_results
```

```
## # A tibble: 5,000 x 5
##    baseline baseline2 benchmark rational_reliance experiment
##       <dbl>     <dbl>     <dbl>             <dbl> <chr>
##  1    0.878     0.556     0.942             0.386 machine
##  2    0.878     0.556     0.942             0.386 machine_and_examples
##  3    0.878     0.556     0.942             0.386 machine_and_heatmap
##  4    0.878     0.556     0.942             0.386 machine_and_random_heatmap
##  5    0.878     0.556     0.942             0.386 machine_with_accuracy
##  6    0.859     0.552     0.934             0.381 machine
##  7    0.859     0.552     0.934             0.381 machine_and_examples
##  8    0.859     0.552     0.934             0.381 machine_and_heatmap
##  9    0.859     0.552     0.934             0.381 machine_and_random_heatmap
## 10    0.859     0.552     0.934             0.381 machine_with_accuracy
## # i 4,990 more rows
```

```
behavioral_data = exp_data %>%
  mutate(behavioral = scoring_rule(user_label, actual_label))
```

```
sample_size = 40
n_round = 1000
behavioral_results = data.frame()
for (i in 1:n_round) {
  behavioral_result = behavioral_data %>%
    group_by(review_num, experiment) %>%
    sample_n(sample_size) %>%
    group_by(experiment) %>%
    summarise(behavioral = mean(behavioral))
  reliance_level = behavioral_data %>%
    group_by(review_num, experiment) %>%
    sample_n(sample_size) %>%
    mutate(sample_id = row_number()) %>%
    group_by(experiment, sample_id) %>%
    summarise(reliance_level = mean((user_label == predicted_label) & (human_pred != user_label))) %>%
    group_by(experiment) %>%
    summarise(reliance_level = mean(reliance_level))
  misreliant = rational_data %>%
    group_by(review_num) %>%
    sample_n(sample_size) %>%
    mutate(sample_id = row_number()) %>%
    select(-experiment) %>%
    cross_join(reliance_level) %>%
    group_by(sample_id, experiment) %>%
    arrange(desc(pos_ai_payoff - pos_human_payoff), .by_group = TRUE) %>%
    mutate(sort_id = row_number()) %>%
    mutate(max_sort_id = max(sort_id)) %>%
    mutate(misreliant_action = ifelse(sort_id <= reliance_level * max_sort_id,
                                      predicted_label,
```

```r
                                              user_label)) %>%
    mutate(misreliant = scoring_rule(misreliant_action, actual_label)) %>%
    group_by(experiment) %>%
    summarise(misreliant = mean(misreliant), reliance_level = mean(reliance_level))
  behavioral_results = behavioral_result %>%
    left_join(misreliant, by = c("experiment")) %>%
    rbind(behavioral_results)
}
```

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```
behavioral_results
```

```
## # A tibble: 5,000 x 4
##    experiment                 behavioral misreliant reliance_level
##    <chr>                           <dbl>      <dbl>          <dbl>
##  1 machine                         0.615      0.816          0.261
##  2 machine_and_examples            0.694      0.889          0.371
##  3 machine_and_heatmap             0.702      0.889          0.37
##  4 machine_and_random_heatmap      0.679      0.889          0.356
##  5 machine_with_accuracy           0.775      0.889          0.354
##  6 machine                         0.634      0.831          0.308
##  7 machine_and_examples            0.69       0.869          0.351
##  8 machine_and_heatmap             0.722      0.869          0.356
##  9 machine_and_random_heatmap      0.716      0.869          0.365
## 10 machine_with_accuracy           0.748      0.869          0.364
## # i 4,990 more rows
```

```
results = rational_results %>%
  group_by(experiment) %>%
  summarise(benchmark = mean(benchmark), baseline = mean(baseline))
results = results %>%
  left_join(behavioral_results %>%
              group_by(experiment) %>%
              summarise(behavioral = mean(behavioral),
                        misreliant = mean(misreliant)))
```

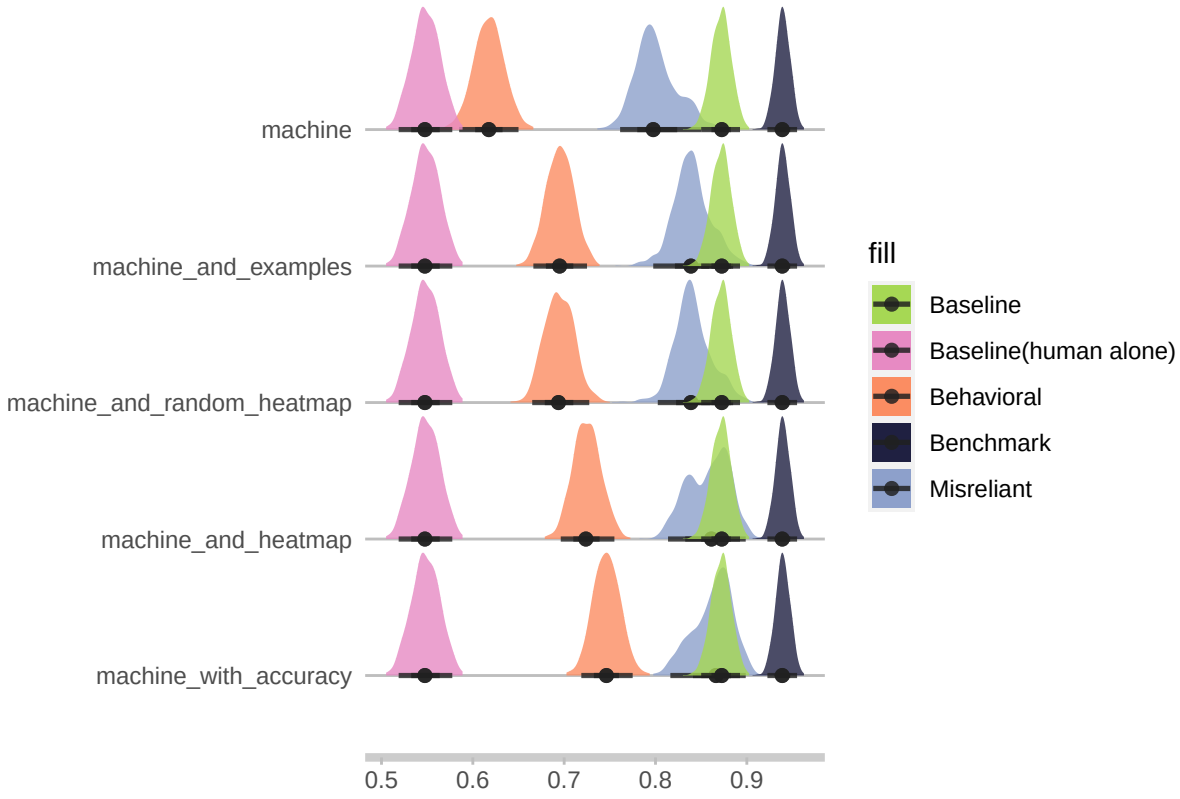
```
## Joining with `by = join_by(experiment)`
```

```
results = results %>%
  mutate(belief_loss = (misreliant - behavioral)/(benchmark - baseline),
         reliance_loss = (benchmark - misreliant)/(benchmark - baseline)) %>%
  arrange(reliance_loss)
results
```

```
## # A tibble: 5 x 7
##   experiment  benchmark baseline behavioral misreliant belief_loss reliance_loss
##   <chr>           <dbl>    <dbl>      <dbl>      <dbl>       <dbl>         <dbl>
## 1 machine_wi~     0.939    0.872      0.746      0.863        1.73          1.13
## 2 machine_an~     0.939    0.872      0.725      0.858        1.97          1.21
## 3 machine_an~     0.939    0.872      0.695      0.841        2.16          1.46
## 4 machine_an~     0.939    0.872      0.695      0.840        2.14          1.47
## 5 machine         0.939    0.872      0.618      0.801        2.72          2.05
```

```
colors <- c("Baseline" = "#a6d854", "Baseline(human alone)" = "#e78ac3", "Benchmark" = "#1F2041", "Beha
ggplot() +
```

```
  stat_slabinterval(data = behavioral_results, aes(y = experiment, x = behavioral, fill = "Behavioral")
  stat_slabinterval(data = behavioral_results, aes(y = experiment, x = misreliant, fill = "Misreliant")
  stat_slabinterval(data = rational_results, aes(y = experiment, x = baseline, fill = "Baseline"), alpha
  stat_slabinterval(data = rational_results, aes(y = experiment, x = baseline2, fill = "Baseline(human a
  stat_slabinterval(data = rational_results, aes(y = experiment, x = benchmark, fill = "Benchmark"), alp
  labs(x = "", y = "", color = "Quantiy") +
  ylim((results)$experiment) +
  theme(panel.grid.major.x = element_blank(),
        panel.grid.minor.x = element_blank(),
        panel.grid.major = element_line(colour = "grey"),
        axis.line.x = element_line(linewidth = 1.5, colour = "grey80"),
        panel.background = element_rect(fill = "white", color = "white"),
        axis.ticks.y = element_blank(),
        axis.ticks.x = element_line(colour = "grey")) +
  scale_fill_manual(values = colors)
```




```
# ggsave("./lai_results.pdf", unit = "in", width = 7.22222222222, height = 3.47222222222 * 5/4)
```

Using discretized signals to approximate

```
rational_action = human_predictions %>%
  group_by(user_label, predicted_label, cluster) %>%
  mutate(pos_human_payoff = scoring_rule(user_label, actual_label),
         pos_ai_payoff = scoring_rule(predicted_label, actual_label)) %>%
  summarise(pos_human_payoff = mean(pos_human_payoff),
            pos_ai_payoff = mean(pos_ai_payoff))
```

```
## `summarise()` has grouped output by 'user_label', 'predicted_label'. You can
## override using the `.groups` argument.
```

```
rational_data = human_predictions %>%
  ungroup() %>%
  mutate(prior_human_payoff = mean(scoring_rule(user_label, actual_label)),
         prior_ai_payoff = mean(scoring_rule(predicted_label, actual_label))) %>%
  mutate(baseline_action = ifelse(prior_human_payoff > prior_ai_payoff, user_label, predicted_label)) %
  mutate(baseline = scoring_rule(baseline_action, actual_label)) %>%
  mutate(baseline2_action = ifelse(prior_human_payoff <= prior_ai_payoff, user_label, predicted_label))
  mutate(baseline2 = scoring_rule(baseline2_action, actual_label)) %>%
  left_join(rational_action) %>%
  mutate(benchmark_action = ifelse(pos_human_payoff > pos_ai_payoff, user_label, predicted_label)) %>%
  mutate(benchmark = scoring_rule(benchmark_action, actual_label)) %>%
  mutate(rational_reliance_level = (benchmark_action == predicted_label) & (user_label != predicted_labe
```

```
## Joining with `by = join_by(user_label, cluster, predicted_label)`
```

```
sample_size = 40
n_round = 1000
rational_results = data.frame()
for (i in 1:n_round) {
  rational_results = rational_data %>%
    group_by(review_num) %>%
    sample_n(sample_size) %>%
    ungroup() %>%
    summarise(baseline = mean(baseline),
              baseline2 = mean(baseline2),
              benchmark = mean(benchmark),
              rational_reliance = mean(rational_reliance_level)) %>%
    rbind(rational_results)
}
rational_results = rational_results %>%
  cross_join(exp_data %>% group_by(experiment) %>% summarise())

behavioral_data = exp_data %>%
  mutate(behavioral = scoring_rule(user_label, actual_label))

sample_size = 40
n_round = 1000
behavioral_results = data.frame()
for (i in 1:n_round) {
  behavioral_result = behavioral_data %>%
    group_by(review_num, experiment) %>%
    sample_n(sample_size) %>%
    group_by(experiment) %>%
    summarise(behavioral = mean(behavioral))
  reliance_level = behavioral_data %>%
    group_by(review_num, experiment) %>%
    sample_n(sample_size) %>%
    mutate(sample_id = row_number()) %>%
    group_by(experiment, sample_id) %>%
    summarise(reliance_level = mean((user_label == predicted_label) & (human_pred != user_label))) %>%
    group_by(experiment) %>%
    summarise(reliance_level = mean(reliance_level))
```

```
  misreliant = rational_data %>%
    group_by(review_num) %>%
    sample_n(sample_size) %>%
    mutate(sample_id = row_number()) %>%
    select(-experiment) %>%
    cross_join(reliance_level) %>%
    group_by(sample_id, experiment) %>%
    arrange(desc(pos_ai_payoff - pos_human_payoff), .by_group = TRUE) %>%
    mutate(sort_id = row_number()) %>%
    mutate(max_sort_id = max(sort_id)) %>%
    mutate(misreliant_action = ifelse(sort_id <= reliance_level * max_sort_id,
                                      predicted_label,
                                      user_label)) %>%
    mutate(misreliant = scoring_rule(misreliant_action, actual_label)) %>%
    group_by(experiment) %>%
    summarise(misreliant = mean(misreliant), reliance_level = mean(reliance_level))
  behavioral_results = behavioral_result %>%
    left_join(misreliant, by = c("experiment")) %>%
    rbind(behavioral_results)
}
```

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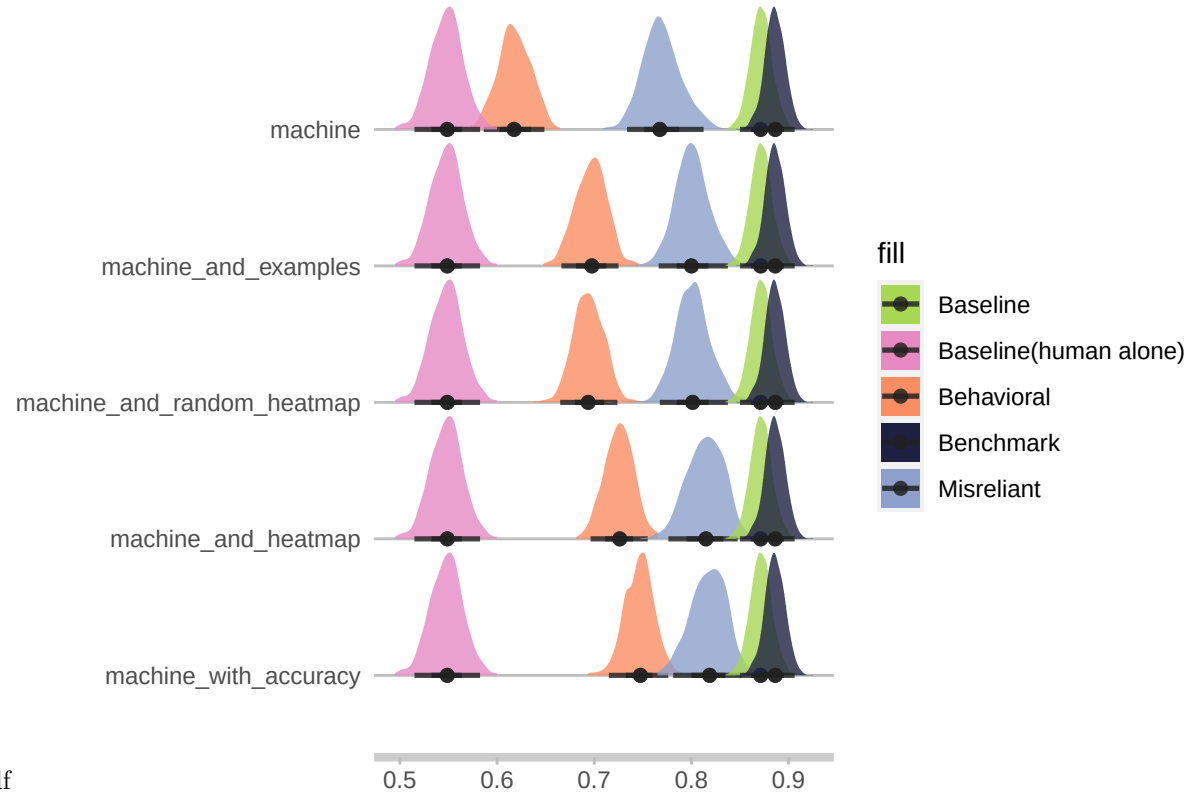
```

```
results = rational_results %>%
  group_by(experiment) %>%
  summarise(benchmark = mean(benchmark), baseline = mean(baseline))
results = results %>%
  left_join(behavioral_results %>%
              group_by(experiment) %>%
              summarise(behavioral = mean(behavioral),
                        misreliant = mean(misreliant)))
```

```
## Joining with `by = join_by(experiment)`
```

```
results = results %>%
  mutate(belief_loss = (misreliant - behavioral)/(benchmark - baseline),
         reliance_loss = (benchmark - misreliant)/(benchmark - baseline)) %>%
  arrange(reliance_loss)
ggplot() +
  stat_slabinterval(data = behavioral_results, aes(y = experiment, x = behavioral, fill = "Behavioral")
  stat_slabinterval(data = behavioral_results, aes(y = experiment, x = misreliant, fill = "Misreliant")
  stat_slabinterval(data = rational_results, aes(y = experiment, x = baseline, fill = "Baseline"), alpha
  stat_slabinterval(data = rational_results, aes(y = experiment, x = baseline2, fill = "Baseline(human a
  stat_slabinterval(data = rational_results, aes(y = experiment, x = benchmark, fill = "Benchmark"), alp
  labs(x = "", y = "", color = "Quantiy") +
  ylim((results)$experiment) +
  theme(panel.grid.major.x = element_blank(),
        panel.grid.minor.x = element_blank(),
        panel.grid.major = element_line(colour = "grey"),
        axis.line.x = element_line(linewidth = 1.5, colour = "grey80"),
        panel.background = element_rect(fill = "white", color = "white"),
        axis.ticks.y = element_blank(),
        axis.ticks.x = element_line(colour = "grey")) +
  scale_fill_manual(values = colors)
```



signals-1.pdf

```
# ggsave("./lai_results_test_performance.pdf", unit = "in", width = 7.22222222222, height = 3.472222222
```