Personalized Rendering of Advertisements

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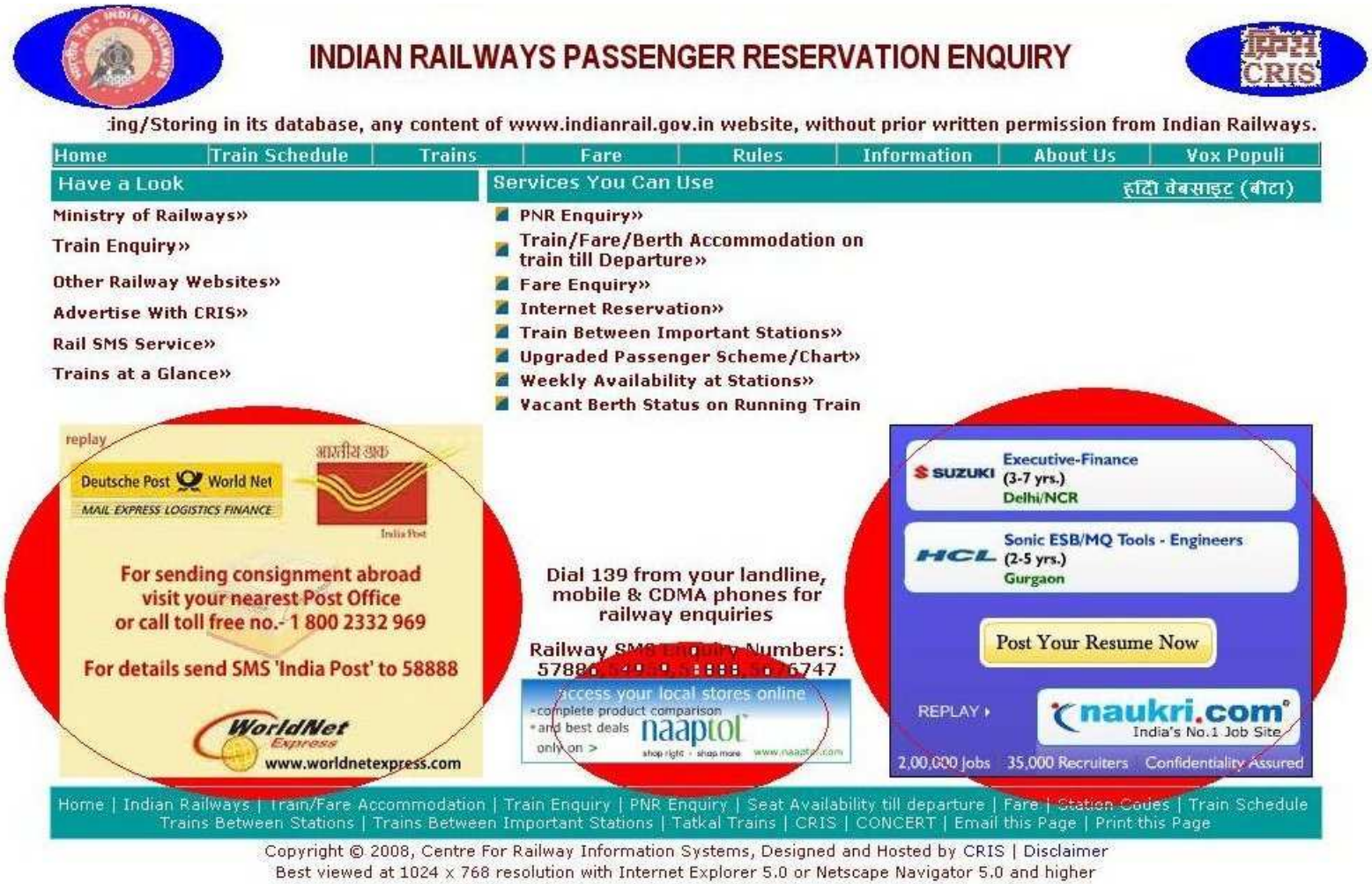
Motivation

- World Wide Web has grown exponentially causing Information overload.
- Goal : Build a tool that allows users to customize the content on web pages.
- Focus : User perspective.
- Learn user preference.
- Interaction with user : Combining Data Mining (DM) + Reinforcement Learning (RL) techniques.
- Annoying aspect of Web : Advertisements.

An Example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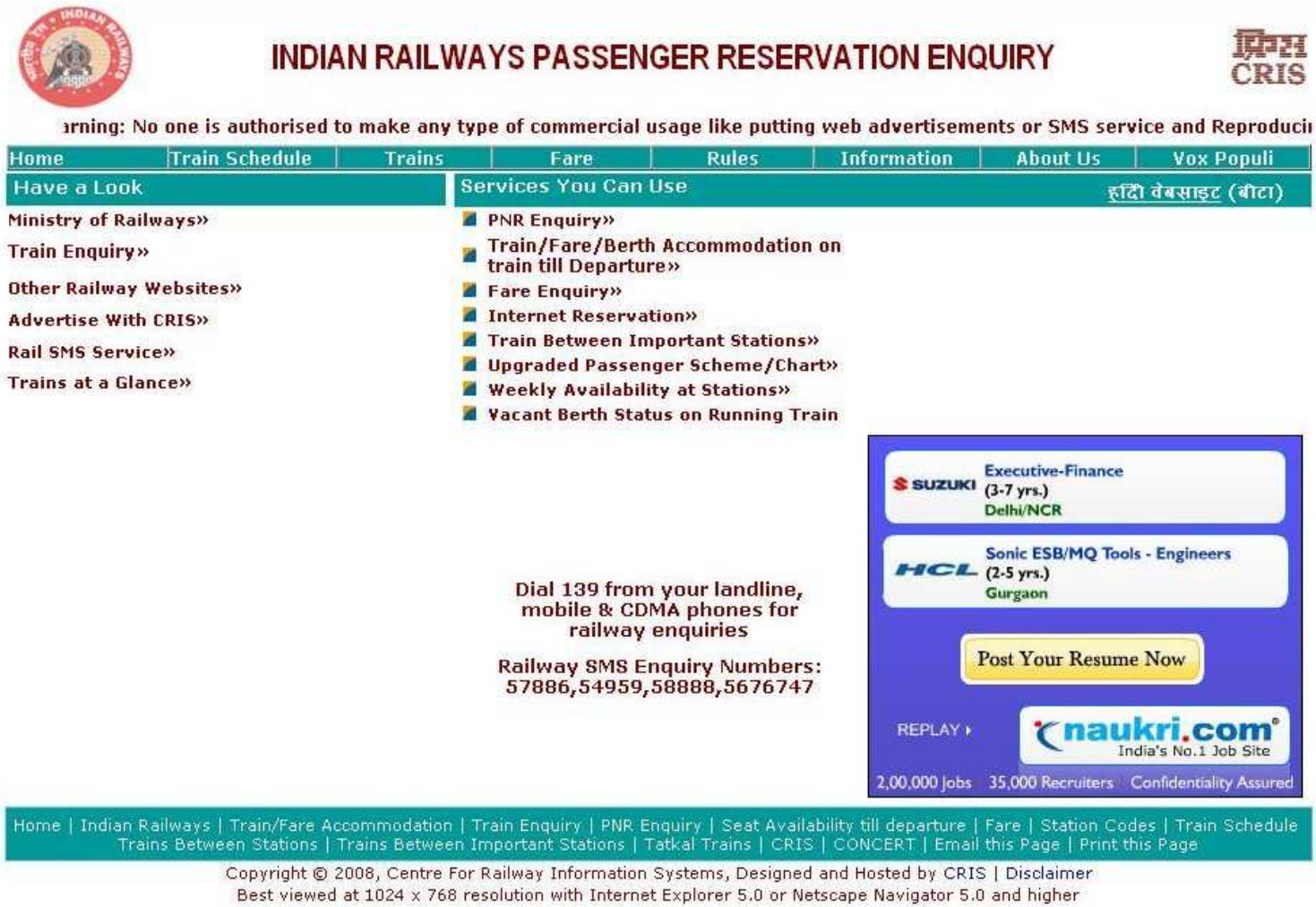
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Proposed Framework

- Two Stage process : Data Mining followed by Decision Making stage.
- Data mining stage : classifies an image as an ad/non-ad.
- Decision making stage decides appropriate action with respect to the image.
- Issues :
  - Complete label information is not available beforehand.
  - If you dont show the ad to user - No feedback if ad is good or bad ad.

Supervised Learning

- Adopt k-nearest neighbors (k-NN) classifier.
- Instance based learning system.
- Supports incremental learning/ No retraining is required.
- k-NN can handle samples that do not follow the actual data distribution.

Reinforcement Learning

- Learn from interaction with the environment to achieve some goal.
- E.g. Baby playing. No teacher. Sensorimotor connection to environment.
- Learn a mapping from situations to actions in order to maximize a scalar reward/ reinforcement signal.
- Formalized as a Markov Decision process $\langle$ S,A,P,R $\rangle$
  - S set of states
  - A set of actions
  - P transition probability, $P^a_{s,s'} = Pr(s'|s,a)$
  - R reward function : $R^a_{s,s'} = E\{r|s,a,s'\}$

Agent learns policy π: S $\rightarrow$ A so as to maximize the expected return.

Active Learning

- There are situations in which unlabeled data is abundant but labeling data is expensive. In such a scenario the learning algorithm can actively query the user/teacher for labels.
- RL decides which samples to show to the user to get labels on.
- Learning algorithm adopted is Q-learning by Watkins (1989).

Data Description

- Internet advertisements data set adopted from UCI repository. Represents a set of possible advertisements on Internet pages.
- The features encode the geometry of the image (if available) as well as phrases occurring in the URL, the images URL and alt text, the anchor text, and words occurring near the anchor text.
- Number of instances : 3279 (2821 nonads; 458 ads).
- Features : 1558 features (3 continuous; others binary)
- One or more of the three continuous features are missing in 28% of the instances.
- Each of the instance is either labeled as ad or non-ad.

Formulation

- There is no real characterization of user via the labeled dataset.
- Feedback from user : reward/penalty.
- Each image is associated with a weight (non ad = +10; ad = +5).
- Key steps to formulating as RL problem : state, action, reward.
- State : 3 tuple (n, g, b)
- Action : Render/Not render
- Reward :

	Render	Not Render
+1	Likes	-
-1	Dislikes	Miss it
0	Ignore	Unaware

- Weight updations cause labels to flip.
  - +ve to -ve : Bad ad
  - -ve to +ve : Good ad
  - current wt $\leq$ -10 : Bad ad
  - previous wt $\leq$ -10 and current wt $>$ -10 : Nonad

Key Idea

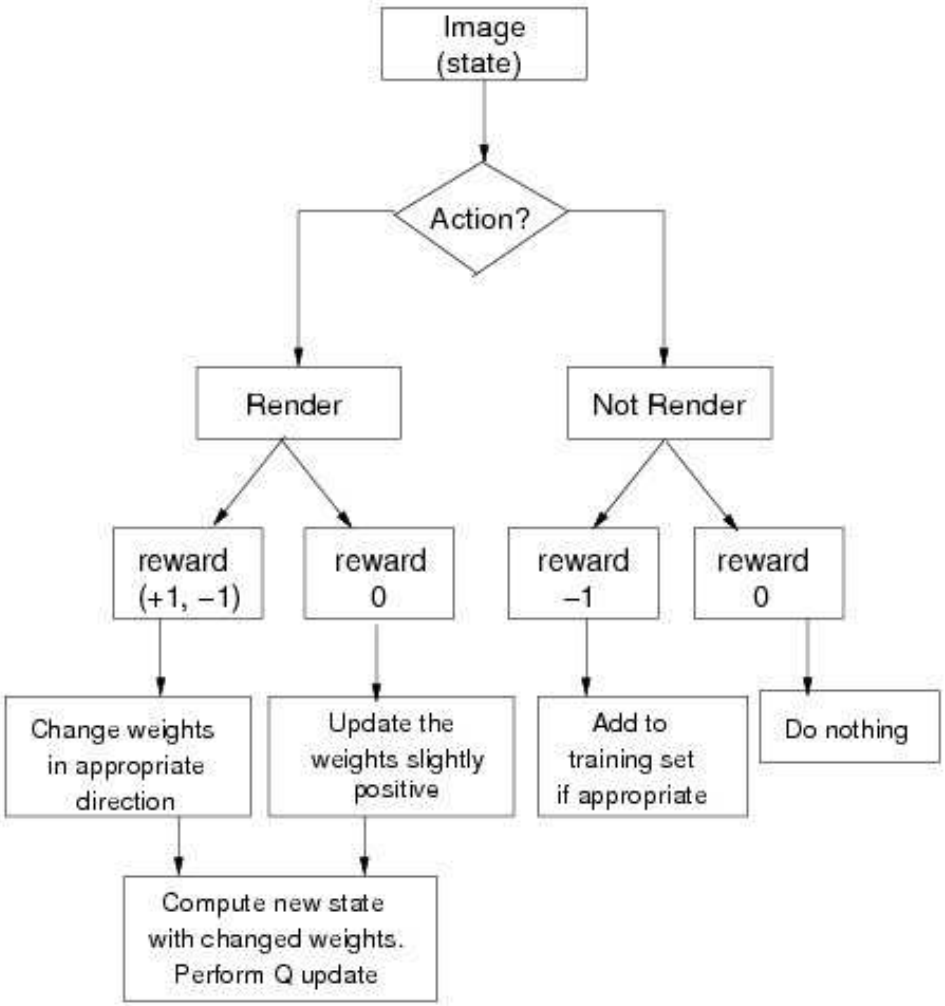


Image
(state)
Action?
Render
Not Render
reward
(+1, −1)
reward
0
reward
−1
reward
0
Change weights
in appropriate
direction
Update the
weights slightly
positive
Add to
training set
if appropriate
Do nothing
Compute new state
with changed weights.
Perform Q update

Algorithm

Initialize, for all $s \in S$, $a \in A$;
$Q(s, a) \leftarrow 0$;
Initialize weights for each representative sample of training data.;
Repeat(for each episode);
$image$ = Pick a random image from training set;
$s = Generate\_State(image)$;
Choose a from s using policy derived from Q (epsilon greedy);
Take action a;
if $a ==$ *render* **then**
    Observe user generated r;
    $Update\_Weights(image, r)$;
    $s' = Generate\_State(image)$;
    $Q(s, a) \leftarrow Q(s, a) + \alpha\ [r + \gamma\ max_{a'}\ Q(s', a')$ - $Q(s, a)]$;
else
    Observe r;
    if r *is negative* **then**
        if *k-NN classification of the image is not a non-ad* **then**
            Add example to representative set;
        else
            $Update\_Weights(image, r)$;
            $s' = Generate\_State(image)$;
            $Q(s, a) \leftarrow Q(s, a) + \alpha\ [r + \gamma\ max_{a'}\ Q(s', a')$ - $Q(s, a)]$;
        end
    end
end

Algorithm Contd.

/* State computation is specific to the Ad problem */

Function *Generate_State*(*image*)

1. Find the k nearest neighbors of the image
2. Retrieve corresponding class-labels
3. Count the number of non-ads (n), good-ads (g) and bad-ads (b) and form a vector (n, g, b)

/* Update Weight function */

Function *Update_Weights*(*image*, r)

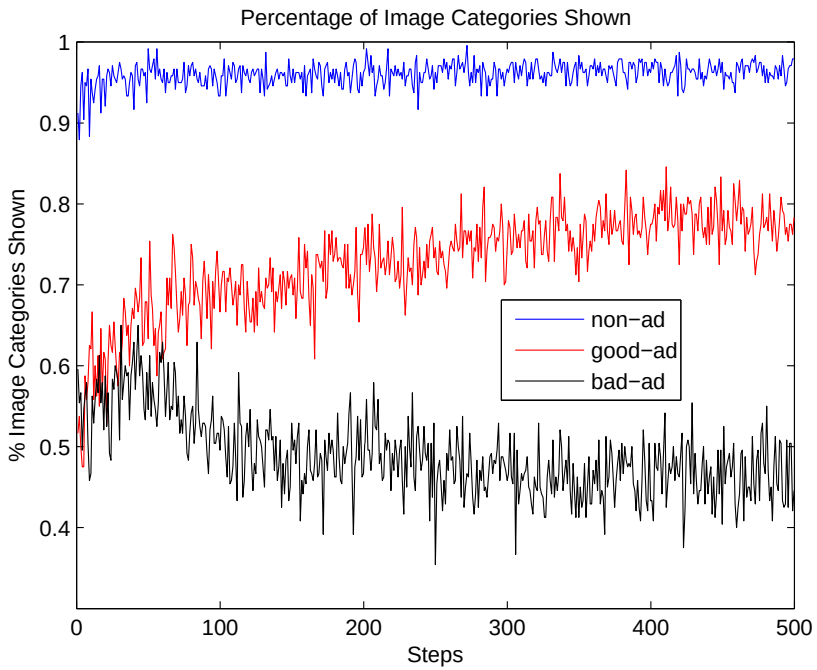
1. Find the k nearest neighbors of the image
2. Update the weights of all the neighboring images slightly positive or negative (with respect to r) by some amount proportional to their distance from this *image*
3. Flip the labels according to the weight changes in the training set

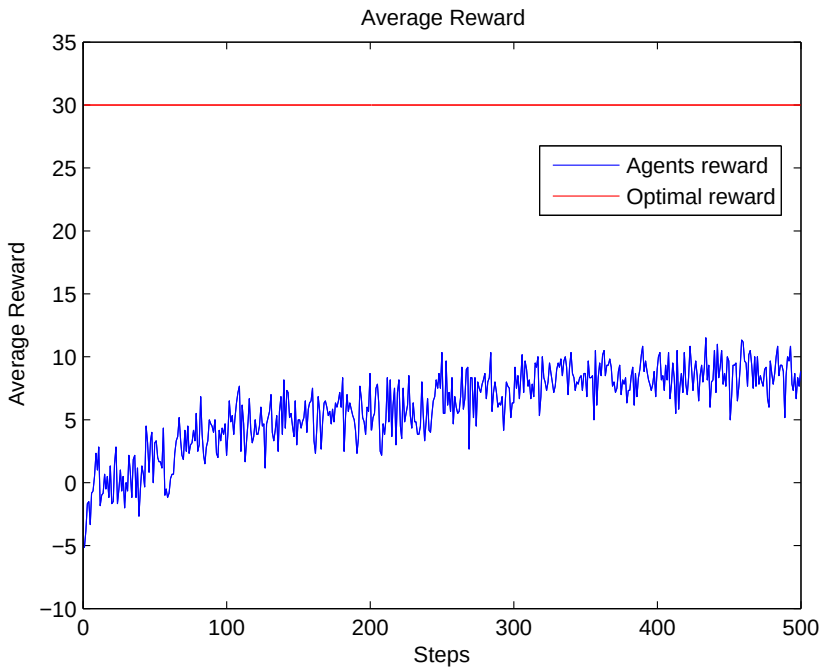
Experimental Setup

- k-NN : Euclidean distance measure, Inital samples : 50, 75
- ϵ-greedy method ($\epsilon = 0.1$)
- Learning rate $= 0.1$; discount $= 0.9$
- Hand crafted hypothetical users.
- Stratified sampling used.
- Randomly sample 100 images from operation data (1 step) used by agent to learn.
- Randomly sample 90 images (30n, 30g, 30b) to evaluate the agent.
- Each run constitutes 500 steps (50,000 images).
- 8 runs.
- Plot 2 graphs :
  - Percentage of image categories shown to the user.
  - Average reward obtained Vs maximum possible reward.

Experimental Results

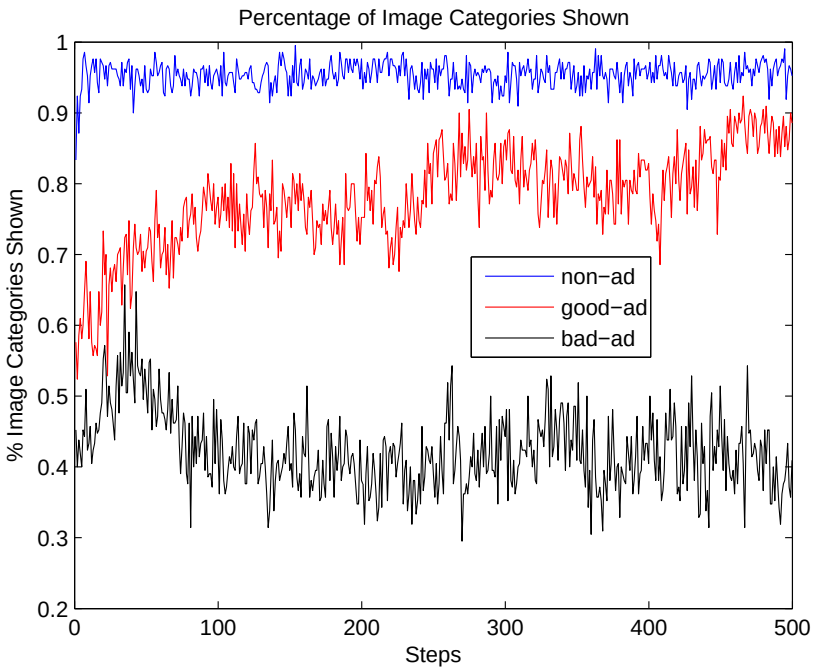
User Profile 1, initial samples : 50

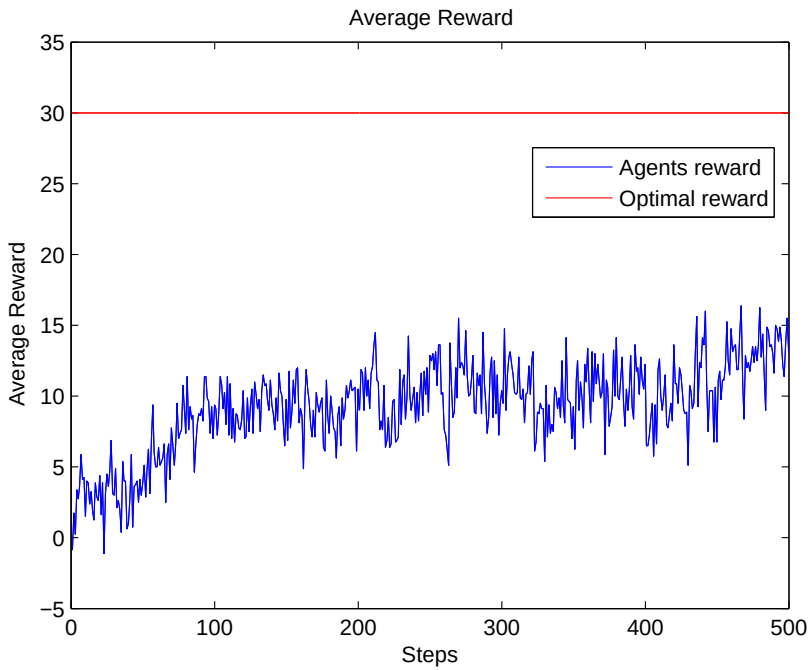




Experimental Results Cont'd..

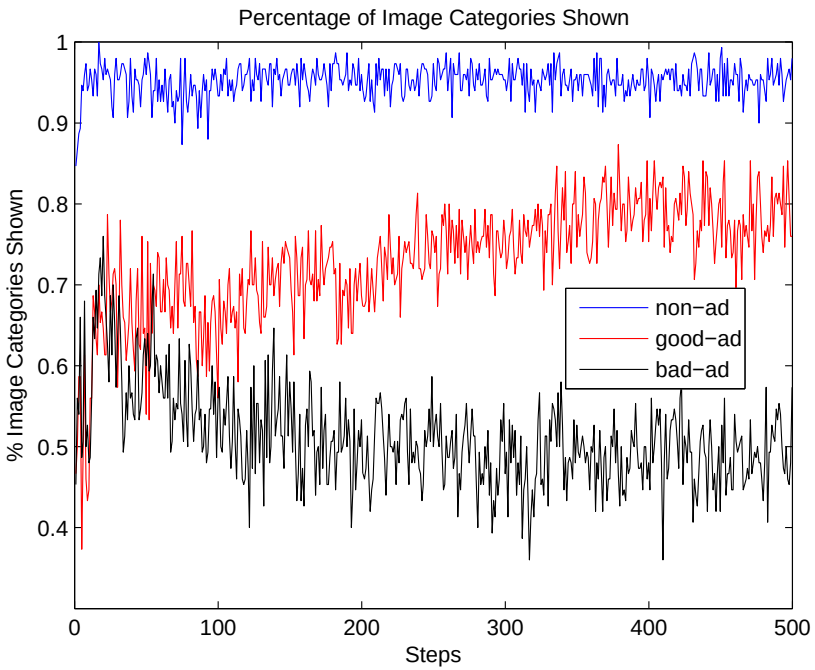
User Profile 2, initial samples : 50

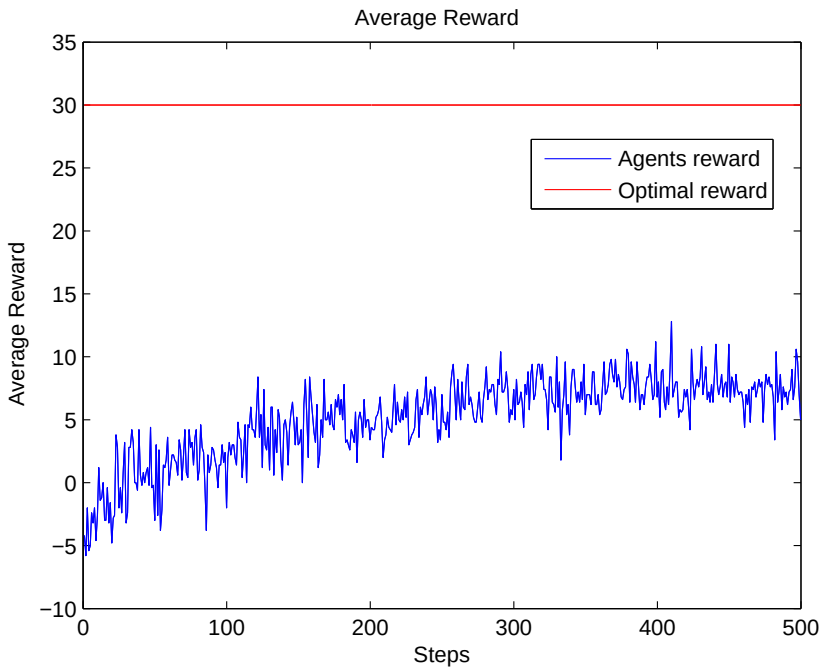




Experimental Results Cont'd..

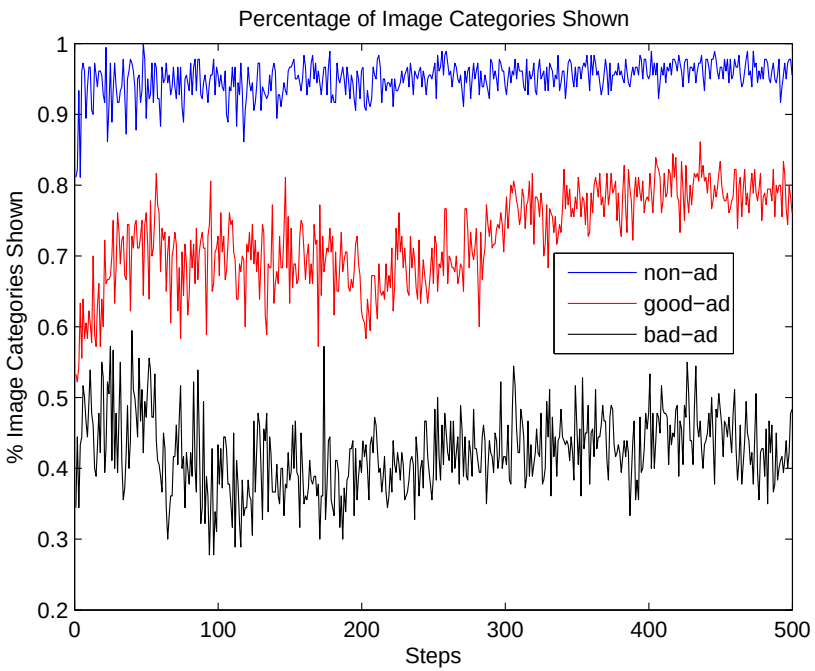
User Profile 1, initial samples : 75

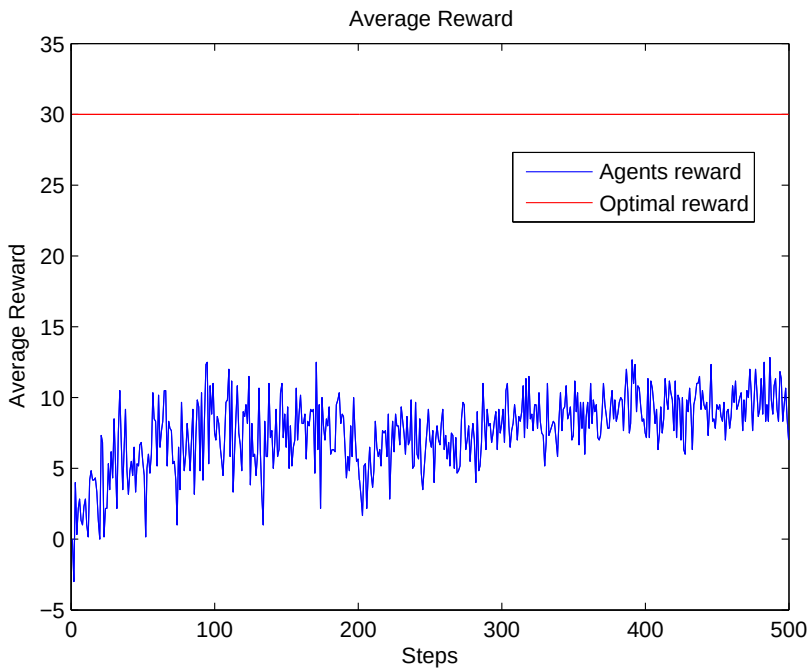




Experimental Results Cont'd..

User Profile 2, initial samples : 75





- Lower k gives better performance : Narrower neighborhood.
- User 2 seems to have smaller set of ads they are interested in - agent can learn quickly.

Conclusion

- Introduced a generic approach to customizing rendering of ads in web pages according to user preference by interaction with the user.
- 2 Stage process : Data mining followed by Decision making.
- Not able to represent appropriate (optimal) function since representation is not powerful enough.
- Better generalization with k-NN or use different classifier that would perform better (Incremental SVM).
- CMAC function approximator instead of a lookup-table.
- Different distance measure : Manifold methods.
- Apart from ads, the agent could be tuned to user sensibilities and used to block offensive content, other media : text, images, multimedia.

Thank you.

Any questions?