

cuACS

Algorithm Design Document

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1 Introduction

1.1 The Animal-Client Matching (ACM) Algorithm

The Animal-Client Matching (ACM) Algorithm is the main feature of the cuACS system. It is designed to compute the optimal set of matches between clients of the animal shelter and animals that are housed within the shelter. It does this by taking into account both the physical and non-physical traits of the animals in conjunction with the preferences for such traits indicated by the clients to compute which animal will be most compatible with a given client. It also takes into account physical and non-physical traits of the clients themselves so that matches can be made which suit both the client and the animal instead of just the client. The main feature of the algorithm is that it takes into account the animal's traits to assign it a specific classification to assist in matching the animal with a client depending on that client's living circumstances, traits, and preferences.

1.2 Document Overview

This document will detail the design and rationale for the algorithm. It will begin by detailing which animals are handled by the shelter and the common physical traits and features that each animal has. It will then talk about the common non-physical traits that define the base personality of each type of animal followed by the species-specific traits that are unique to a specific species of animal housed by the shelter. How each of the non-physical traits interact with the algorithm and how they affect the animal's classification will also be detailed.

Following that, the various client traits and preferences will be described in a similar way to the animal traits. Specifically, the interaction between these traits and the profile constructed for the client by the algorithm will be detailed.

The section following that will provide an overview of the basic operation of the algorithm. It will describe, in simplified steps, what the algorithm does to compute the optimal set of matches. Then, a detailed breakdown of each of the simplified steps will be laid out with accompanying diagrams and tables so that each individual step of the algorithm can be explained in detail.

Finally, a simple example run-through of the algorithm's operation will be performed to match three different clients with four different animals so that the algorithm's operation can be seen in action on a simple, easy to follow sample.

2 Animals

2.1 Overview

The cuACS system is designed to accommodate the animals that the animal shelter is able to hold. The species of animals that the shelter handles are described in this document as common household pets. Each of these animals have common physical and non-physical traits and also have individual species-specific traits which, together, determine how fit an animal is for a client.

This section will first give a brief overview of the species that the animal shelter houses, it will then detail the classification categories that animals can fall into. Then, it will describe the traits of the animals, first describing the physical traits, then the non-physical traits, and finally the species-specific traits. For each set of traits, a description, set of possible values, and relation to the operation of the algorithm (i.e. how the algorithm uses the trait in computing a match) are given.

2.2 Species of Common Household Pets

The shelter that will be using the cuACS system houses various breeds and types of five species of animal: Dog, Cat, Bird, Lizard, and Rabbit. Each of these different species have common physical and non-physical attributes but they also have specific attributes which are unique to that specific species of animal. This means that the matching algorithm must take all of these differences into account and must handle each type of animal at least partially differently. The algorithm will not attempt to match a client with a species of animal that the client didn't indicate a preference for.

2.3 Traits of the Common Household Pets

2.3.1 Common Physical Traits

Table 1—Physical Traits Common to All of the Species of the Common Household Pets

Trait	Species
Description	The species of the animal.
Possible Values	Dog, Cat, Lizard, Bird, Rabbit.
Application to the Algorithm	The clients can choose a specific species of animal that they wish to be matched with.
Trait	Breed
Description	The breed or sub-species within the animal's overall species.
Possible Values	Infinite, as the staff members will be able to define their own species. For example, possible values for the breed of lizard can be: Green Iguana, Leopard Gecko, Chameleon, etc.
Application to the Algorithm	The clients can choose a preferred breed or species of animal.
Trait	Size
Description	The physical size of the animal.
Possible Values	Teacup, Small, Medium, or Large. These values are relative to the normal expected size of the particular animal's species.
Application to	The clients can choose a preferred size of animal.

the Algorithm	
Trait	Age
Description	The actual or estimated age of the animal in years.
Possible Values	Any integer between 0 and 99.
Application to the Algorithm	The clients can choose a preferred age range that they wish their pet to fall in.
Trait	Gender
Description	The biological sex of the animal.
Possible Values	Male or Female.
Application to the Algorithm	The clients can choose a preferred gender that they wish the animal to have.
Trait	Fur/Scales/Feathers
Description	The type of fur, scales, or feathers that the animal has. The type of outer coating is determined by the species of the animal.
Possible Values	For dogs, cats, and rabbits possible values are: Hairless, Short, Long. For Lizards, the field will become "Scales" and the possible values are: Spiked, Rough and Smooth. For Birds, the field will become "Feathers" and the possible values are: Yes and No.
Application to the Algorithm	The client can choose a preferred fur, scale, or feather type depending on which species of animal they preferred.
Trait	Hypoallergenic
Description	the scale to which the animal is considered hypoallergenic.
Possible Values	Yes or No.
Application to the Algorithm	A client can indicate a preference for a hypoallergenic animal.

2.3.2 Common Non-Physical Traits

Table 2—Non-Physical Traits Common to All of the Species of the Common Household Pets

Trait	Likes Traveling
Description	This trait indicates the scale to which the animal is a good travel companion. Is it okay on long road trips? Does it handle the stress of travel well?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the desired value of this trait. The algorithm will also take into account a client’s vacation habits when making a match based on this trait.
Trait	Good with Children
Description	This trait indicates the scale to which the animal is good around children. Is the animal gentle around smaller, weaker humans? Is the animal aggressive or twitchy around children?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the desired value of this trait. The algorithm will take into account whether or not a client has children when making a match even if a client indicates a preference for this trait.
Trait	Good with Animals
Description	This trait indicates the scale to which the animal is good around other animals of the same or differing species. Is the animal overly territorial? Is the animal
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the desired value of this trait. The algorithm will take into account whether or not a client has other animals when making a match even if a client indicates a preference for this trait.

Trait	Good with Strangers
Description	This trait indicates the scale to which the animal is good around strangers. Does the animal get overly defensive of its owner around others? Is the animal receptive to new people?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the desired value of this trait.
Trait	Good in Crowds
Description	This trait indicates the scale to which the animal is good in medium to large crowds of people. Is the animal easily panicked when surrounded? Does the animal become aggressive when surrounded by others?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the desired value of this trait.
Trait	Good with Loud Noises
Description	This trait indicates the scale to which the animal handles loud noises like thunderclaps, gunshots, or fireworks well. Does the animal become easily spooked by a loud noise? Does it cower in those cases?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the desired value of this trait. The algorithm will also take into account the location of a client’s dwelling when computing a match against this trait.
Trait	Good Home Protector
Description	This trait indicates how competent the animal is at defending a home and protecting the inhabitants. Does the animal stand a good chance against an intruder like a burglar? Is the animal loyal enough to protect its owners?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to	A client can indicate a preference for the desired value of this trait.

the Algorithm	
Trait	Lots of Energy
Description	This trait indicates how much energy an animal has. Does it require frequent walks? Does the animal tire easily?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the desired value of this trait. The algorithm will also take into account the size of a client’s dwelling when matching against this trait.
Trait	Is Fearful
Description	This trait indicates whether or not the animal is easily spooked. Is the animal jumpy? Does it react well to sudden movements?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the desired value of this trait.
Trait	Is Affectionate
Description	This trait indicates the level of affection that the animal displays to its owner. Is the animal cuddly? Does the animal tend to give kisses or otherwise readily express affection?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the desired value of this trait.
Trait	Is Messy
Description	This trait indicates how messy an animal is. Does the animal tend to cause a mess of household objects and its environment? Does the animal’s living area require a lot of maintenance?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the desired value of this trait.

Trait	History
Description	Describes the origin of the animal before it was taken in by the shelter.
Possible Values	Given up by owner, Street animal, Rescue, or Unknown.
Application to the Algorithm	A client can indicate a preference for the desired value of this trait.
Trait	Indoor or Outdoor Type
Description	Indicates the animal's preference for more outdoor or indoor time.
Possible Values	Indoor, Outdoor, or Both.
Application to the Algorithm	<p>A client can indicate a preference for the desired value of this trait.</p> <p>The algorithm will also take into account the client's own activity preferences in order to make an informed match. It will also take into account the location of the client's dwelling.</p>
Trait	Nocturnal
Description	Describes the sleeping habits of the animal. Does the majority of the animal's sleeping time occur during the night or day?
Possible Values	Yes or No.
Application to the Algorithm	<p>A client can indicate a preference for the desired value of this trait.</p> <p>The algorithm will also take into account the client's own work schedule in order to match an animal's sleeping schedule with a client's.</p>

2.3.3 Species-Specific Traits

Table 3—Traits Specific to Dogs

Non-Physical	
Trait	Barks a Lot
Description	This trait describes the average amount that the dog barks. Is the dog barking at anything and everything all the time? Is the dog relatively silent?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the level of noise their potential dog makes. The algorithm will take into account the type of dwelling a client has when computing a match against this trait.
Trait	Follows Commands
Description	This trait describes the degree to which the dog is trained. Does it easily follow advanced commands? Does it struggle with simple commands like “Sit” or “Stand?”
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the level of obedience that their potential dog would have.
Trait	House Trained
Description	This trait describes whether or not the dog has been house trained? Does it ask to go outside when it needs to relieve itself or does it relieve itself anywhere without a care?
Possible Values	Yes or No
Application to the Algorithm	A client can indicate a preference for whether or not they want their dog to be house trained.

Table 4—Traits Specific to Cats

Physical	
Trait	Sheds Fur
Description	This trait describes the level to which the cat sheds its fur. Is it a heavy shedder or a light one?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the amount of shedding they are okay with their potential cat having.
Non-Physical	
Trait	Is Curious
Description	This trait describes the level to which the cat is curious about its surroundings? Does it tend to explore or stay within a familiar area?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the level of curiosity of their potential cat.
Trait	Is Well Trained
Description	This trait describes the level of training the cat has received. Is the cat responsive to commands? Would the cat leave dead animals around the client’s dwelling?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the level of training that their potential cat has.

Table 5—Traits Specific to Birds

Physical	
Trait	Colour
Description	This trait describes the overall colour of the bird.
Possible Values	Red, Orange, Yellow, Green, Blue, Pink, Purple, White, Black, Brown, or Gray. For example, if the bird has mostly red feathers with a few accents of white or black then the bird would be classified as “Red.”
Application to the Algorithm	A client can indicate a preference for the colour they would like their potential bird to be.
Non-Physical	
Trait	Is Loud
Description	This trait describes the average loudness of the bird. Does the bird tend to squawk? Is the bird a quiet or loud singer?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the loudness of their potential bird. The algorithm will take into account the type of dwelling that the client lives in when matching against this trait.
Trait	Needs Attention
Description	This trait describes the degree to which the bird needs attention. Is the bird fairly independent or does it call on it’s owner often?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the level of attention their potential bird will need.

Table 6—Traits Specific to Lizards

Physical	
Trait	Colour
Description	This trait describes the overall colour of the lizard.
Possible Values	Red, Orange, Yellow, Green, Blue, Pink, Purple, White, Black, Brown, or Gray. For example, if the lizard has mostly red scales with a few accents of green or black then the lizard would be classified as “Red.”
Application to the Algorithm	A client can indicate a preference for the colour they would like their potential lizard to be.
Trait	Needs Strong Heat Lamp
Description	This trait describes whether or not the lizard requires a stronger than normal heat lamp.
Possible Values	Yes or No.
Application to the Algorithm	A client can indicate a preference for whether or not they wish to support a lizard which needs a strong heat lamp.
Non-Physical	
Trait	Needs Large Living Space
Description	This trait describes whether or not the lizard requires a larger-than-normal enclosure independent from their size. Does the lizard require lots of space to hide or hunt?
Possible Values	Yes or No.
Application to the Algorithm	A client can indicate a preference for whether or not they wish to support a lizard which needs a large living space. The algorithm will also take into account the size of the client’s dwelling independent of the client’s preferences when matching against this trait.
Trait	Preferred Diet
Description	This trait describes the preferred diet of the lizard.
Possible Values	Crickets, Worms, or Mice.
Application to the Algorithm	A client can indicate a preference for the preferred diet they wish their potential lizard to have.

Trait	Feeding Interval
Description	This trait describes the typical frequency for which the lizard should be fed.
Possible Values	Daily, Weekly, Bi-weekly, Monthly, or > Monthly.
Application to the Algorithm	A client can indicate a preference for the frequency with which their potential lizard should be fed.

Table 7—Traits Specific to Rabbits

Physical	
Trait	Colour
Description	This trait describes the overall colour of the rabbit.
Possible Values	Black, Brown, Gray, White, Cream, or Straw. For example, if the rabbit has mostly white fur with spots of black, the rabbit would be classified as “White.”
Application to the Algorithm	A client can indicate a preference for the colour they would like their potential rabbit to be.
Trait	Pattern
Description	This trait describes the pattern of the colour(s) on the rabbit.
Possible Values	Solid, Bi-colour, Tortoiseshell, Striped, or Spotted.
Application to the Algorithm	A client can indicate a preference for the pattern they wish their potential rabbit to have.
Non-Physical	
Trait	Needs Grooming
Description	This trait describes how much the rabbit needs to be groomed. Will the rabbit shed too much to be manageable by the rabbit on its own?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the level of grooming their potential rabbit should need.
Trait	Needs Attention
Description	This trait describes the degree to which the rabbit needs attention. Is the rabbit fairly independent or does it call on it’s owner often?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Not at all” and 5 indicates “A lot”.
Application to the Algorithm	A client can indicate a preference for the level of attention their potential rabbit will need.

2.4 The Classification of Animals Based on Their Traits

To aid in accurate matching of animals with clients, a system of classification for animals was devised. There are six classifications of animals. Not every animal species will fit into every classification. The classifications, and their most important defining traits are as follows:

Table 8—Classifications of Animals

Classification	Rural Rover
Description	Rural Rovers include medium to large sized animals which are energetic and require a lot of exercise. They thrive in outdoor settings such as farms and acreages and behave well around other animals.
Most Weighted Traits	Indoor or Outdoor Type, Lots of Energy, Good with Animals, Is Messy.
Classification	Family Pal
Description	Family Pals are animals which love the affection from their owners—both adults and children. They are animals of any size which thrive in rural or suburban environments. They do not mind the hectic lifestyles of young families.
Most Weighted Traits	Good with Children, Lots of Energy, Good with Loud Noises, Good in Crowds, Likes Traveling, Age.
Classification	Urban Dweller
Description	Urban Dwellers love the city life. From exciting walks in the park to accompanying owners on brunch dates. They do not mind living the high-rise life and do well with noise and crowds.
Most Weighted Traits	Good in Crowds, Good with Loud Noises, Indoor or Outdoor Type, Is Messy, Lots of Energy.
Classification	Cuddly Companion
Description	Cuddly Companions are animals which are often more lethargic and therefore do not require as much exercise or space. This makes them perfect for urban environments (although this isn't exclusive).
Most Weighted Traits	Is Affectionate, Lots of Energy, Good with Children, Size.
Classification	Fierce Convoy
Description	Fierce Convoys think it is their duty to protect and serve. They are large animals (typically dogs) that do best in rural and suburban environments and

	require lots of exercise.
Most Weighted Traits	Good Home Protector, Lots of Energy, Size, Age.
Classification	Experienced Sidekick
Description	Experienced Sidekicks have seen it all, and are ready to take it easy. These pets are well-suited for any dwelling, do not require as much intense exercise, and are much cleaner than younger animals. These animals pair perfectly with older clients.
Most Weighted Traits	Lots of Energy, Is Affectionate, Is Messy, Indoor or Outdoor Type, Age.

3 Clients

3.1 Overview

Every client indicates their matching preferences when they create their profile. These matching preferences are taken into account when matching animals with clients. These matching preferences are used to compute the classification of animal that a client is looking for. Furthermore, the client fills out a small profile indicating several different personal traits. These traits are taken into account when matching against an animal's physical and non-physical attributes so that, for example, a very large dog isn't matched with a client who lives in a very small apartment. This, plus the aforementioned matching preferences, will help ensure not only that an animal is good for a client, but also that a client is good for an animal.

This section will first explain what a client's matching preferences can be, what their options are, and which animal traits they match with. It will then detail the the various client traits that the client fills out as part of the "Personal Information" section of their profiles.

3.2 Client Matching Preferences

When a client first logs into the system, they will be asked to fill out a set of matching preferences. These matching preferences are essentially the exact same as what a staff member would see when they are creating an animal. A client can choose, for example, the amount that their animal "Likes Traveling" or, if the client indicated that their preferred matching species is a lizard, then the client could indicate a preference for the "Scales" of the lizard. Every animal trait, aside from the name of the animal, is used in computing a match

between clients and animals. Therefore, a client can indicate a preference for any of the traits described in section 2 *Animals*.

Additionally, a client can choose “No Preference” for any of the traits of an animal. This means that the algorithm will not take into account that trait when matching an animal. The exact mechanics of how this works is discussed in section 4 *Operation of the Algorithm*. A client may also indicate a preference for zero or more species such that the algorithm will not try to match a client with any species of animal for which the client did not indicate a preference.

3.3 Client Traits

Similar to the matching preferences, when a client first logs into the system they will be asked to fill out a set of personal information that will be used to better match them with an appropriate animal. The fields that a client will have to fill out are as follows:

has children

has other animals

activity level

work schedule

Table 9—Personal Traits of Clients

Trait	Dwelling Type
Description	This trait describes the type of dwelling in which the client lives.
Possible Values	Small Apartment/Condominium, Large Apartment/Condominium, Townhouse, Detached House, or Farm.
Application to the Algorithm	
Trait	Dwelling Location
Description	This trait describes the general level of development of the location of the client’s dwelling.
Possible Values	Urban, Suburban, or Rural.
Application to the Algorithm	
Trait	Has Young Children
Description	This trait indicates whether or not the client has young children present in the dwelling. Young is defined as under 16 years of age.

Possible Values	Yes or No.
Application to the Algorithm	
Trait	Has Other Animals
Description	This trait indicates whether or not the client has other animals living in the dwelling.
Possible Values	Yes or No.
Application to the Algorithm	
Trait	Level of Activity
Description	This trait describes the typical level of activity of the client? Does the client live a sedentary life? Do they go on daily jogs?
Possible Values	An integer value on a scale from 1 to 5 where 1 indicates “Little” and 5 indicates “A lot”.
Application to the Algorithm	
Trait	Work Schedule
Description	This trait describes the client’s typical work schedule.
Possible Values	Typical “9-5”, Afternoon to Late Evening, Overnight Shifts, Early Morning to Early Afternoon, Varying.
Application to the Algorithm	This trait is matched against an animal’s non-physical Nocturnal trait to determine whether or not the client would have time to play with the animal while the animal is still awake. This trait is not heavily weighted in matching.

4 Operation of the Algorithm

4.1 Overview

4.2 Individual Steps

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