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Technology empowering animal welfare: a multi-agent information collaboration framework for lost-pet recovery

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Abstract. After a pet goes missing, owners can actually think of quite a few channels for finding it: posting on WeChat Moments, asking for help in community groups, checking surveillance footage, putting up lost-pet notices, or contacting pet hospitals and rescue organizations. Having many channels is a good thing in itself, but it also creates problems: information formats do not match, the same lead gets forwarded over and over, and nobody can say clearly how the search is going. To understand owners' search channels, technical needs, attitudes toward information collaboration, and privacy concerns, I conducted a survey via Wujuanxing and received 53 valid responses. In the survey, 77.36% of respondents chose social media or community groups, and 67.92% would check nearby surveillance footage, but only 13.21% used lost-pet platforms or mini programs. Image recognition and similarity matching received an importance score of 4.49/5, and geofencing notifications scored 4.36/5. In addition, all 53 respondents agreed that the first 24 hours after a pet goes missing are critical. Based on these findings, my framework includes these components: a unified information template, aggregation of multi-source leads, lead prioritization, coordination of verification tasks, updated feedback on results, and tiered information sharing. However, the sample is small and no real cases were used for validation, so the framework remains exploratory for now, and whether it actually works still needs to be tested in follow-up research.

Keywords: lost pets, animal welfare, information fragmentation, multi-agent collaboration, information network

1. Introduction

After a pet goes missing, the owner suffers both emotional distress and financial loss, and the animal itself may face traffic, weather, and other environmental risks. Weiss et al. [1] discussed the loss and recovery of dogs and cats, pointing out that different animals may differ in how they are found. Lord et al. [2] noted that identity tools such as microchips help contact pet owners, but how much they help depends on whether the registration information and contact details are still valid. Therefore, finding a lost pet cannot be treated only as a problem of locating a moving target; every link, from the generation and spread of information to verification and action, needs to be considered.

In an actual search, the owner may post in WeChat Moments and community groups at the same time, put up notices, ask the property management to retrieve surveillance footage, and seek help from pet hospitals,

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rescue organizations, or volunteers. Each channel has its own use, but the way information is recorded and updated is not the same across them. The same lost-pet information may be forwarded many times, and sighting leads may be scattered across different platforms. If this information is not organized, users may find it hard to tell in time which leads are still valid. It should be noted that the questionnaire in this paper mainly surveyed channel use and technical needs, and did not directly measure the rate of duplicate posting or the frequency of cross-platform status inconsistency; information fragmentation is therefore treated in this paper mainly as the problem that the system design targets, rather than as a result already fully measured by the survey.

Research in crisis informatics focuses on how the public produces, spreads, and organizes information with social media and digital tools during emergencies [3, 4]. These studies suggest that whether information can be turned into action depends not only on how widely it spreads, but also on information organization and cross-agent collaboration. Following this line of thought, this paper does not aim to build yet another lost-pet platform competing with existing channels, but explores whether a coordination link can gather the information produced by different channels to make verification and feedback easier.

When designing the questionnaire, I mainly wanted to find out four things: which channels respondents usually use to search for lost pets; what insights the current use of channels could offer for my later design of information coordination; which technical functions and ways of sharing information respondents would accept; and whether, on this basis, a collaboration framework with a clear structure and the possibility of further implementation could be proposed.

2. Literature review

2.1. Pet loss and recovery

Surveys in the United States found that both dogs and cats have experiences of going missing within a certain period, but they differ in how they are recovered: dogs more often involve active human searching, while cats may return home on their own [1]. A related survey by the American Society for the Prevention of Cruelty to Animals (ASPCA) also mentioned that neighbor searches, posting lost-pet posters, and online spread of lost-pet information are all important ways to find a lost pet[1]. These two studies made me notice a common point: the recovery of a lost pet is almost never completed by the owner alone, but involves help from other people and multiple sources of information.

Meanwhile, research on animal sheltering and identification also points out that tools such as microchips help identify animals, but their actual effect is also affected by the completeness of the owner's registration information and the validity of contact details [2]. From the perspective of information processing, one pet recovery process can include sighting, posting, matching, contacting, confirming, and handover, and each link may need different agents to take part.

2.2. Information fragmentation and crisis informatics

When looking for a pet, WeChat groups, WeChat Moments, property management, pet hospitals, rescue organizations, and volunteers may each hold part of the leads. The trouble is that these leads are scattered across different platforms, people, and organizations, in all kinds of formats, and they may not be updated at

[1] ASPCA. (2012, June 28). How many pets are lost? How many find their way home? ASPCA survey has answers [Press release].

the same time, so it is hard to view them together. In the survey I did ask about channel use, but there was also a limit: the questionnaire could only tell me which channels people used; as for how much information across channels conflicts with each other, I had no way to know.

Crisis informatics research mentions that in emergencies digital information appears in large amounts, and filtering, interpreting, and organizing information become especially important [3, 4]. Research on crowdsourced crisis response has reached similar conclusions: information from multiple channels must first be classified, organized, and cross-validated before it can truly support practical action. And public participation is not just more information; behind it there are also problems of collaboration and reorganization [5-7]. Moved to the lost-pet scenario, the real difficulty is not letting more people see the information, but gathering fragmented leads together and verifying them one by one.

2.3. Multi-agent collaboration and network structure

Searching for a lost pet requires multiple agents to act at the same time: pet owners post messages everywhere, neighbors help keep watch and forward, property management checks surveillance, and volunteers and pet hospitals receive leads. The information flows among so many roles can be presented with network relations. Kapucu [8] studied cross-agency coordination in emergencies, and Wukich et al. [9] and Liu et al. [10] analyzed information ties among different organizations on social media, all showing that network relations already have an applied basis in emergency research. But since interactive data from real lost-pet cases is currently lacking, this paper first draws the possible relational structure among agents and does not compute network weights or collaboration efficiency for now.

2.4. Information diffusion, noise, and verification

The more lost-pet information is posted and spread, the more serious the problem of mixed and unreliable content becomes. Similar pet photos may be misidentified, the same sighting information may be forwarded repeatedly, and a location from a few days ago may still keep appearing in various groups. Arathoon et al. [11] studied the visibility of lost and stolen pets in cyberspace; Torpan et al. [12] also pointed out that false information brings trouble to emergency management. For a lost-pet system, it is not enough to just collect leads; a verification or marking step must be added when each sighting lead is taken in.

2.5. Research gap

Existing literature separately covers pet loss and recovery, information organization in emergencies, and multi-agent collaboration, but few studies put these angles together in the lost-pet scenario. This paper first uses 53 questionnaires to learn about respondents' search channels, technical needs, and privacy attitudes, and then proposes a multi-agent collaboration framework and a preliminary idea of lead priority scoring.

3. Research methods

3.1. Research design

The research started from questionnaire design. The questionnaire mainly asked about respondents' search channels, technical needs, attitudes toward information sharing, and privacy concerns. After the questionnaires were collected, their results were analyzed descriptively, and finally the collaboration framework was designed.

3.2. Questionnaire and sample

The questionnaire was administered via Wujuanxing, and 53 valid responses were received in total; all respondents took part voluntarily with informed consent. The questions covered: the respondent's relationship with the pet, whether they had experienced a pet going missing, which channels they used to search, their views on photo (image) matching and similar functions, notification frequency, willingness to pay for pet searching, willingness to share information, and what privacy issues they worried about. Question types included single choice, multiple choice, open-ended questions, and 5-point Likert scale items.

In the sample, there were 26 cat owners and 22 dog owners, together 90.57%. 94.34% of respondents had encountered pet loss through their own experience, the experience of relatives or friends, or social information. But because the sample is small and collected online, these results are more suitable for exploring user needs and cannot yet be generalized to all pet owners or all regions.

3.3. Variables and analysis methods

This paper mainly reports the number and percentage of channel users, average scores on the 5-point scale, and a small number of descriptive comparisons between experience groups. For multiple choice questions, the 53 valid questionnaires were used as the denominator, so the sum of percentages may exceed 100%. Given the small sample, this paper does not make statistical significance tests or causal inferences.

In the system design part, information agents or channels are taken as nodes in a network, and information spreading, seeking help, verification, and feedback are taken as the ties between agents. The lead priority score is used to show how a future system could organize candidate leads.

4. Results and analysis

4.1. Sample characteristics

Among the 53 valid questionnaires, 13 respondents had themselves experienced a pet going missing, 14 had relatives or friends who had, 23 had heard of similar events, and 3 said they had never experienced or heard of any. Therefore, 50 respondents, or 94.34%, had encountered pet loss in some way. 26 respondents were cat-related (49.06%) and 22 dog-related (41.51%). Pet types in the sample were mainly cats and dogs.

4.2. Current search behavior is spread across multiple channels

In the multiple choice question on search channels, 41 respondents (77.36%) chose social media or community groups, 36 (67.92%) chose retrieving nearby surveillance or access control footage, 27 (50.94%) chose posting notices offline or ground promotion, and 17 (32.08%) chose contacting nearby pet shops, hospitals, rescue stations, or administrative departments. Another 7 (13.21%) chose to use lost-pet platforms or mini programs, and 6 (11.32%) used geofencing or tracking devices. Since respondents could choose multiple channels, the percentages do not add up to 100%.

From these answers, respondents usually consider more than one way of searching. Social media and community groups are the most chosen channels, surveillance and offline notices also take a certain share, while the use of professional lost-pet platforms is low. The data can show that search behavior has a multi-channel character, but by itself cannot prove that information conflicts or duplicate spreading must exist across channels.

4.3. Use of community channels and design implications

Social media or community groups had the highest choice rate in this survey. This suggests that the system design could consider continuing to use the communication channels residents are familiar with, instead of asking everyone to move to a brand-new platform. A coordination hub could take on the function of organizing information and summarizing leads, with existing channels as the sources and entrances of information. However, this questionnaire measured channel use and did not directly compare the recovery success rate of each channel, so it cannot be concluded from this that any one channel works better than others in actual recovery.

4.4. Time sensitivity and the "first 24 hours" window

All 53 respondents agreed that the first 24 hours after a pet goes missing are critical. This shows that respondents generally value early response, but the questionnaire alone cannot tell whether the first 24 hours apply to all pets. For system design, this result suggests that early information posting and lead handling should be taken seriously.

4.5. A gap between technical needs and actual adoption

Image recognition and similarity matching received an average importance score of 4.49/5, and geofencing notifications 4.36/5. But in actual use, only 6 people used geofencing or tracking devices, and only 7 had used lost-pet platforms or mini programs. There is still a considerable distance between what respondents demand from functions and what they actually adopt. But my questionnaire did not further ask why, so whether this gap comes from tools being hard to find, poor results, high cost, or some other reason cannot be judged at present.

4.6. Notification preferences across experience groups

Nearly half of the respondents (47.17%) said they hoped to receive notifications once per hour during an emergency search. Among respondents who had personally experienced pet loss, 69.23% chose hourly notifications, while among those who had only heard of similar events, only 34.78% did, a difference of more than double. But each group is small, and factors like personal experience and urgency may affect answers at the same time, so I present this only as a descriptive difference.

4.7. Data collaboration is accepted, but privacy is an important boundary

The average agreement score for community neighbor help was 4.15 (out of 5), institutional data collaboration 4.00, and location notifications 4.08. All three passed 4, showing that people generally accept collaboration and information sharing. 43.4% of respondents clearly said they had privacy concerns, and 11.32% were strongly opposed.

Respondents are willing to share but also afraid of leakage, so system design cannot only pursue the convenience of information sharing. Pet photos, basic features, and the rough area where the pet went missing can be open for the public to view, but more detailed leads and contact information must be given only to the relevant people according to verification tasks and authorized scope. How exactly to divide permissions still needs to be decided in light of actual use scenarios.

4.8. Effect considerations in payment decisions

30 respondents (56.60%) said whether they would pay depends on the search results. But willingness to pay is self-reported, and with this number from 53 samples alone, it is still impossible to judge whether a business model holds.

5. Multi-agent collaborative system design

5.1. Design goals

There is an obvious contrast in the survey results: people mainly rely on social media, community groups, and surveillance to find pets, while professional lost-pet platforms are rarely used. This shows that what is missing is not one more new platform, but the connection between existing channels. Connecting information from different channels to the same information hub, recording and organizing leads in a unified way, makes viewing and verification more convenient for users.

5.2. Multi-agent information network structure

In the process of searching for a pet, the pet owner, the information coordination hub, existing communication channels (such as community groups and social media), and verification-assisting agents (such as property management and volunteers) are involved. I use a directed graph $G = (V, E)$ to represent the information flows among these four types of nodes. V is the set of nodes, E is the set of edges, and each edge represents a possible direction of information transmission.

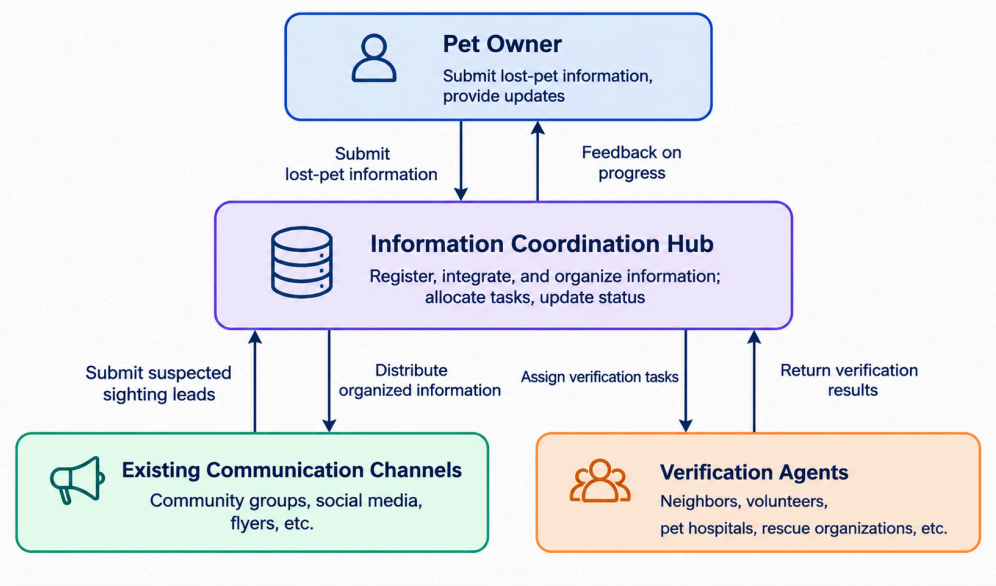

Figure 1. Schematic diagram of the multi-agent information collaboration structure for lost pets

As shown in Figure 1, the pet owner first submits the lost-pet information to the coordination hub, the hub organizes it and sends it back to existing channels. When the public sees anything suspicious, they submit possible sighting leads. Property management, volunteers, and related organizations assist verification as tasks require. Verification results return to the hub, the system updates lead status, and then feeds the progress back to the pet owner.

This figure is a conceptual diagram drawn according to the system design proposed in this paper, not a measured network built from the interaction records of real cases. Since the questionnaire did not record the actual frequency of contact between agents, this paper does not quantitatively analyze network edge weights or the strength of collaboration between agents. The structure is mainly used to illustrate the relations among information gathering, lead verification, and result feedback, and provides a basis for the later lead priority score and task coordination.

5.3. Multi-source lead priority score

When multiple possible sighting reports appear at the same time, verifiers may not be able to handle all leads immediately. This paper therefore proposes a simple priority scoring method that evaluates leads comprehensively from four aspects: image similarity, spatial match, lead timeliness, and information completeness:

$$q_i = w_1 S_{img,i} + w_2 S_{loc,i} + w_3 S_{time,i} + w_4 S_{info,i} \tag{1}$$

Here, q_i is the priority score of the i-th lead; $S_{img,i}$, $S_{loc,i}$, $S_{time,i}$, and $S_{info,i}$ represent image similarity, spatial match, lead timeliness, and information completeness respectively; w_1 to w_4 are the corresponding weights, subject to the condition that all weights are non-negative and sum to 1.

Image similarity compares how similar the possible sighting photo is to the photo of the lost pet; spatial match looks at the distance between the sighting location and the most recent reliable location; timeliness considers how long ago the sighting information was reported; information completeness checks whether elements such as time, location, and pictures in the lead are complete. In practical use, all four indicators need a unified scoring rule before weighted calculation. However, since this paper did not collect real sighting photos, locations, or verification results, specific weights cannot be set for now, and the actual effect of this scoring method cannot be verified; it can only serve as a preliminary idea of lead ordering, and does not represent the credibility of a lead.

5.4. Task coordination, privacy protection, and feedback mechanism

After leads are ordered, verification work still needs to be arranged by task type. Surveillance verification can be assisted by property staff with the corresponding conditions and permissions, and on-site searching can be handed to nearby volunteers who can take part. When choosing who verifies, lead priority, participant capability, available time, and information access permissions need to be considered together.

Information sharing needs clear boundaries. The general public can see pet photos, basic features, and the rough area where the pet went missing. Volunteers or partner organizations, once authorized, can view some additional information as tasks require. Sensitive content such as contact details and precise locations must be kept tighter. After a case is closed, information should be updated in time to reduce unnecessary continued exposure.

Each lead can be marked as to be verified, under verification, confirmed, or ruled out. After verification results return, the system updates the records; ruled-out leads are not assigned again, and newly appearing leads are ordered again.

6. Discussion

6.1. Main findings reflected by the survey results

When looking for a lost pet, respondents rarely use only one channel; people often rotate among social media, community groups, surveillance, and offline notices, while professional lost-pet platforms are rarely used. Functions such as image recognition and geofencing all received fairly high subjective importance scores. When designing a system, what deserves more effort is organizing and connecting the information of existing channels, rather than adding one more posting entrance.

6.2. Implications for animal welfare

The faster sighting leads are collected and the earlier they are verified, the smaller the chance that the pet runs into traffic, weather, and other risks while lost. Sorting out the organization of lost-pet information and the collaboration process therefore has a positive meaning for animal welfare. However, this study did not measure the effect of a real system on recovery time or recovery rate, so this meaning is still at a potential level, and it cannot be said directly that animal welfare has been improved.

6.3. Implications for computer science and mathematical modeling

Using a network structure to represent participating agents and the information ties between them, and putting image, location, time, and information completeness into the same scoring framework, is the attempt of this paper. The network structure is the path through which information flows between agents, while the scoring framework outputs the priority of possible leads. Compressing complex, heterogeneous information into a comparable, processable model, this approach may also serve as a reference for the design of other multi-agent information systems.

6.4. Research limitations

The limitations of this paper mainly lie in the following aspects. In terms of sample, there were only 53 questionnaires collected online, covering mainly dog and cat owners; the situation of other pet types is basically not presented. The questionnaire itself reflects respondents' self-reports and function preferences, not continuous records of real search processes, so it cannot prove that a certain technology improves the recovery rate. In addition, this paper did not directly quantify cross-platform duplicate information, lead verification time, or final recovery results; the information network and lead scoring remain exploratory designs. Finally, since no prototype test was carried out, how this framework actually compares with traditional multi-channel lost-pet methods cannot be judged at present.

7. Conclusion and future work

This paper conducted a descriptive analysis of 53 questionnaires around the problem of information organization and collaboration after a pet goes missing. The results show that respondents often use channels such as social media, community groups, surveillance, and offline lost-pet notices; image matching and geofencing received fairly high subjective importance scores, but fewer people used lost-pet platforms and tracking tools. In the sample, all respondents agreed that the first 24 hours after a pet goes missing are critical.

There are quite a few existing lost-pet channels, but they lack connection with each other, and the use rate of professional lost-pet platforms is low. A collaboration framework based on community networks can record lost-pet information in a unified way, aggregate multi-source leads, queue them by priority, coordinate

verification, feed back results, and decide what is visible to whom according to the authorized scope. Information organization, lead verification, and agent collaboration were originally separate links; in this framework they become one process, and later prototype design and case studies can move forward along this process.

Future research can expand the survey to more regions and pet types. After obtaining authorization, real lost-pet cases can be collected to observe whether lead scoring and information organization really work in verification. When conditions are mature, a simple prototype can be developed for comparison with existing channels, focusing on lead handling time, duplicate records, verification completion, and whether information access meets authorization requirements.

References

[1] Weiss, E., Slater, M., & Lord, L. (2012). Frequency of lost dogs and cats in the United States and the methods used to locate them. *Animals, 2*(2), 301–315. https://doi.org/10.3390/ani2020301

[2] Lord, L. K., Ingwersen, W., Gray, J. L., & Wintz, D. J. (2009). Characterization of animals with microchips entering animal shelters and related return-to-owner statistics. *Journal of the American Veterinary Medical Association, 235*(2), 160–167. https://doi.org/10.2460/javma.235.2.160

[3] Palen, L., & Anderson, K. M. (2016). Crisis informatics—New data for extraordinary times. *Science, 353*(6296), 224–225. https://doi.org/10.1126/science.aag2579

[4] Reuter, C., & Kaufhold, M.-A. (2018). Fifteen years of social media in emergencies: A retrospective review and future directions for crisis informatics. *Journal of Contingencies and Crisis Management, 26*(1), 41–57. https://doi.org/10.1111/1468-5973.12196

[5] Heinzelman, J., & Waters, C. (2010). Crowdsourcing crisis information in disaster-affected Haiti (USIP Special Report No. 252). United States Institute of Peace.

[6] Meier, P. (2011). New information technologies and their impact on the humanitarian sector. *International Review of the Red Cross, 93*(884), 1239–1263. https://doi.org/10.1017/S1816383112000318

[7] Starbird, K. (2012). What "crowdsourcing" obscures: Exposing the dynamics of connected crowd work during disaster. arXiv. https://arxiv.org/abs/1204.3342

[8] Kapucu, N. (2006). Interagency communication networks during emergencies: Boundary spanners in multiagency coordination. *The American Review of Public Administration, 36*(2), 207–225. https://doi.org/10.1177/0275074005280605

[9] Wukich, C., Hu, Q., & Siciliano, M. D. (2019). Cross-sector emergency information networks on social media: Online bridging and bonding communication patterns. *The American Review of Public Administration, 49*(7), 825–839. https://doi.org/10.1177/0275074019861701

[10] Liu, W., Xu, W., & St. John, B. (2021). Organizational disaster communication ecology: Examining interagency coordination on social media during the onset of the COVID-19 pandemic. *American Behavioral Scientist, 65*(7), 957–982. https://doi.org/10.1177/0002764221992823

[11] Arathoon, J., Allen, D., & Hallatt, A. (2024). Too hot to handle: Making lost and stolen pets present in virtual space. *Geoforum, 152*, 104013. https://doi.org/10.1016/j.geoforum.2024.104013

[12] Torpan, S., Hansson, S., Rhinard, M., Kazemekaityte, A., Jukarainen, P., Meyer, S. F., Schieffelers, A., Lovasz, G., & Orru, K. (2021). Handling false information in emergency management: A cross-national comparative study of European practices. *International Journal of Disaster Risk Reduction, 57*, 102151. https://doi.org/10.1016/j.ijdrr.2021.102151

Appendix A: Key statistical data of the questionnaire

Table A. Key statistical data of the questionnaire

Indicator	Result	Interpretation
Valid sample	53	Exploratory sample
Encountered pet loss	94.34%	Self, relatives or friends, or heard of it
Cat-related respondents	26 / 49.06%	One of the main sample groups
Dog-related respondents	22 / 41.51%	One of the main sample groups
Social media / community groups	41 / 77.36%	Highest usage rate
Surveillance / access control	36 / 67.92%	Second highest usage
Offline notices / ground promotion	27 / 50.94%	Traditional offline channels still matter
Pet shops / hospitals / rescue stations	17 / 32.08%	Institutional collaboration channels
Lost-pet platforms / mini programs	7 / 13.21%	Low actual adoption
Geofencing / tracking devices	6 / 11.32%	Low actual adoption
Importance of image recognition	4.49 / 5	Highest function score
Importance of geofencing	4.36 / 5	Second highest function score
Hourly notifications	47.17%	Highest single notification preference
Effect-oriented payment	56.60%	Largest paying group
First 24 hours as the critical period	53 / 53	100% agreement in this sample
Privacy concerns	43.4%	Important governance constraint