Artificial Intelligence and Environmental Ethics

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ABSTRACT. AI systems have the potential to address ethical issues. Case-based reasoning systems may be the most promising approach to environmental ethics. Power issues, considered in applied ethics, are a fundamental feature of issues arising from landscape-level management, and may be studied using stakeholder modeling techniques, while rule-based systems may be appropriate for deontological ethical issues (based on duties or obligations). Semantic networks may be used to study and summarize the views of individuals in groups. Conflict between individual advantage and the common good can be explored through Game Theory.

Environmental ethics is "the field of inquiry that addresses the ethical responsibilities of human beings for the natural environment. It is concerned with values: Does nature have value that extends beyond its obvious role of meeting human needs? Do some parts of nature have more value than others?" (Armstrong and Botzler 1993). Such questions are debated in new journals such as *Environmental Ethics*, *Journal of Agricultural Ethics*, *Environmental Values*, and *The Trumpeter: Journal of Ecosophy*. They are at the heart of the views of Aldo Leopold (1949), whose writings, and in particular his view that "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise," are widely supported by those advocating an ethical approach to environmental management (Reeves et al. 1992).

In practice, however, terms like "integrity," "stability," and "beauty" vary in interpretation. A range of AI methodologies can form the basis of decision support systems in this complex arena. However, "[c]lassical, humanistic ethics finds ecosystems to be unfamiliar territory. It is difficult to get the biology right and, superimposed on the biology, to get the ethics right" (Ralston 1993). Similarly, environmental ethics is unfamiliar territory to ecologists. The present study reviews a range of AI systems that have potential to address ethical issues and form a bridge between these disciplines.

Case-Based Reasoning

In the field of applied ethics, resolution of ethical problems relies on comparison with previous cases (Winkler and Coombs 1993, Flybjerg 1993) or exemplars (Flybjerg 1993), leading to the conclusion that case-based reasoning systems may be the most promising approach to environmental ethics. Knowing the context of a particular case is the key to resolving ethical dilemmas: "contextualism adopts the general idea that moral problems must be resolved within the interpretive complexities of concrete circumstances, by appeal to relevant historical and cultural traditions, with reference to critical institutional and professional norms and virtues, and by relying primarily upon the method of comparative case analysis. According to this method, we navigate our way to a practical resolution by discursive triangulation from clear and settled cases to problematic ones" (Winkler and Coombs 1993). Similarly, Flybjerg (1993) indicates that applied ethics is always situational ethics. Case-based reasoning systems are already used in law (Ashley and Rissland 1988), which in many respects is similar to ethics, while an exemplar-based system has been described by Bareiss (1989).

An example of a situation where a case-based ethical reasoning system might assist in forestry decisions is illustrated by recent modifications to the code of ethics of the Society of American Foresters (SAF). The SAF (1993) recently adopted a new Land Ethic Canon, which states that "A member will advocate and practice land management consistent with ecologically sound principles." However, differences exist in interpretation of what constitutes "ecologically sound principles," even within the forestry community (Cornett et al. 1994, Proctor 1996), to the extent that one member "turned himself in" to the society's ethics committee (South 1994), as he normally advocated use of practices including single-species planting, fertilizer application, and short rotations, which might result in a stand that differed from an expected mixed-species stand on a site and cause disruption to certain understory species. In South's opinion, these management practices violated "ecologically sound principles." Although the individual was found "not guilty" of violating the code of ethics, the SAF ethics committee could offer no ecological principle consistent with these common practices.

By defining land-based "contexts," such as parks, private lands, timber supply areas or aboriginal lands, one could devise a set of appropriate actions for each context. As well as allowing for context, a case-based system could account for gender and cultural differences found in forest values (Berry 1993). When an action in one context may have consequences in another, the system would provide a basis for resolving new situations, and provide guidance to professional foresters who were unsure about the appropriateness of an action. However, Codes of Ethics cannot resolve moral dilemmas; this requires application of a moral theory more general than the code of a particular profession (Beyerstein 1993). Most dilemmas arise when we are faced with incompatible actions, all of which seem to involve ends that should not be sacrificed.

While formal ethical analysis has not yet been widely applied in forestry, it forms the basis of many decisions in wildlife management, especially in the national parks of the U.S. Ralston (1993) describes a number of cases from Yellowstone Park, where there is a predominating ethic of letting nature take its course. Three of these cases illustrate some of the ethical issues involved:

Case 1: A bison fell through the ice, but would-be rescuers were forbidden from rescuing it or putting it out of its misery.

Case 2: A sow grizzly and her three cubs crossed ice to an island to feast on two elk carcasses, and were stranded and starving after the ice melted. They were rescued and released on the mainland, in order to protect an endangered species.

Case 3: Giant forest fires raged in Yellowstone uncontrolled in 1988. Elk and bison leaving the park to escape the fires were shot by hunters. National authorities eventually overrode the Yellowstone land ethic and controlled the fires.

Comparing Case 2 with Case 1 indicates that a species value ethic overrode the non-intervention ethic. A case-based reasoning system would shed light on situations where a forest fire threatened the habitat of an endangered species, or where the endangered species was not a large mammal but, for example, a snail, or where the context was a rangeland area rather than a park. Species conser-

vation and biodiversity issues are currently a major component of landscape management (Thomson et al. 1996); thus, ethics and landscape management will be considered in more detail.

Ethics, Power, and Landscape Management

Flybjerg (1993) argues that applied ethics should focus on values and examine power issues by answering questions such as: Who gains and who loses? By virtue of which mechanisms of power? What are the possibilities of changing existing power relations, if desirable? Of what kind of power relations is the applied ethics itself a part? Such an approach would be useful in addressing certain forestry problems related to power struggles involved in long-range forest planning (Allen and Gould 1986) or global forest harvesting (Bowyer 1991) that result from the fact that people are unlikely to agree on how power and resources should be redistributed (Jaggar 1993).

Every cultural group perceives landscapes differently. This affects how each group views potential modifications (Greider and Garkovich 1994). When decisions must be made at a landscape level (where forestry is only one of a number of disciplines involved, as in the adaptive management approach which involves many stakeholder groups (Shindler et al. 1996)), power factors determine what constitutes the information used to define the landscapes, as well as the issues, alternatives, and groups with standing in the landscape management process (Greider and Garkovich 1994).

Acquisition and distribution of power is a natural process in any group, organization, or institution, determining the goals to be sought and how resources will be distributed (Robbins 1993). This can result in either barriers or incentives for ecosystem management, which is as much a social as it is a scientific endeavor (Cortner et al. 1996). A range of AI approaches to organizational phenomena and dynamics (Prietula 1993) may help to resolve organizational power issues in the landscape management decision process.

Rule-Based Systems

One class of ethical theories, deontological ethics (based on duties or obligations), judges actions by their conformance to some formal rule or principle;[1] thus a rule-based approach to environmental ethics had initial appeal. However, values are often opaque to the person who holds them, and there can be inconsistencies and incoherencies in a system of values (Jamieson 1993). While rule-based systems can deal with inconsistencies and incoherencies, knowledge elicitation for rule formulation may be impractical when values are opaque to the holder.

Rule-based systems do offer promise in the area of comparative or descriptive ethics, however. The aim here is to elaborate beliefs and practices in relation to cultural, social, economic, and geographic circumstances.[2] Colfer et al. (1989) describe a rule-based system of this sort; for example:

RULE NUMBER: 11

IF: Ethnicity is Javanese transmigrant

THEN: Landowner is normally considered to be a male household head

and Land is viewed as very limited

and Rights to land are traditionally certified and private

and Women's agricultural labor is recognized as necessary but not preferred

and Ethnicity is symbolized by farming and small-scale female trade

and World view is hierarchical and authoritarian

and Domestic animals may include <2 cows and goats and chickens and 2 or more cattle

and Most crops planted probably require intensive management

and People value fertilizer and hoeing and cattle

Semantic Networks

The ethical beliefs of an individual are shaped by social and economic circumstances.[3] Semantic networks can explore the shaping of the beliefs of individuals and communities. For example, the relationships of an indi-

[1] Encyclopaedia Britannica Micropaedia Ready Reference. 1986. Volume 4, p 579.

[2] Encyclopaedia Britannica Micropaedia Ready Reference. 1986. Volume 3, p 502.

[3] Encyclopaedia Britannica Micropaedia Ready Reference. 1986. Volume 3, page 502.

vidual X, who can belong to a number of networks, can be expressed as PROLOG facts (Thomson 1993, 1996):

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member_of_family(A,X).
member_of_clan(M,A).
member_of_religious_group(B,X).
small_holder(X).
female(X).
member_of_community_group(C,X).
member_of_community_group(D,X).
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The values of an individual reflect the weighted sum of his/her affiliations, while the values of a group or community reflect the weighted sum of the individuals that make it up.

Game Theory and Genetic Programming

International issues, such as response to global warming, hinge on ethical dilemmas (Danielson 1993, Jamieson 1993). Our value system, as it impinges on the environment, is a relatively recent construction. It evolved in low population density and low technology societies, with seemingly unlimited access to land and resources. Our existing system focuses on the conception of responsibility: harms and their causes are individual, local in space and time. Global environmental problems are different; apparently innocent acts can have devastating consequences, causes and harms may be diffuse, and causes and harms may be remote in space and time. Many people doing small things over a long period of time together will cause unimaginable harms, and it is difficult to find anyone to blame (Jamieson 1993). Response to such issues is a "prisoner's dilemma" situation, with the conflict between common good and individual advantage being central to these environmental questions (Danielson 1993). "Prisoner's dilemma" situations play an increasingly important role in discussions of ethical theory.[4] Danielson (1992) explores a game theory approach to ethical situations of this type, and develops PROLOG-based populations of players that compete in an arena using different ethical constructs. Genetic programming could then be used to determine the optimal approach to different situations (Danielson 1995).

Summary

Environmental issues raise a host of difficult ethical questions;[5] and ethics, as a system of values or principles, comprises many issues fundamental to practical decision making.[6] An evaluation of potential AI approaches to environmental ethics thus provides improved understanding of the decision process and facilitates successful deployment of AI-based decision support systems.

"The central problem [in applied ethics] is to gain a fuller understanding of the nature of the biases and distortions that affect decision procedures in particular social and cultural contexts, and thus to clarify the conditions under which we can be confident that we have at least approximated a consensus" (Winkler and Coombs 1993). Consensus-building is a predominant trend in recent forest land-use decision initiatives (Eberle et al. 1992). Stakeholder modeling facilitates consensus-building through explicit representation of differing value systems and their evaluation through indicator performance analysis (Akenhead et al. 1996). An alternative approach, reaching consensus through discourse, is the basis of discourse ethics (Kettner 1993). Systems falling in the category of "Computational Dialectics" (Gordon 1994) may assist in the mediation process.

[4] Encyclopaedia Britannica Micropaedia Knowledge in Depth. 1986. Volume 18, page 647E.

[5] Encyclopaedia Britannica Micropaedia Knowledge in Depth. 1986. Volume 18, page 647F.

[6] Encyclopaedia Britannica Micropaedia Ready Reference. 1986. Volume 4, page 578.

References

Akenhead, S.A., A.J. Thomson, D. Morgan, B. Adams, and W.M. Strome. 1996. Planning sustainable forestry when there are complicated rules and many stakeholders. Pages 399-404 in: Proceedings, Eco-Informa '96, Lake Buena Vista, Florida, November 1996.

Allen, G.M., and E.M. Gould, Jr. 1986. Complexity, wickedness and public forests. Journal of Forestry 84(4): 20-23.

Armstrong, S.J., and R.G. Botzler. 1993. Environmental ethics: Divergence and convergence. McGraw-Hill, New York.

Ashley, K.D., and E.L. Rissland. 1988. A case-based approach to modelling legal expertise. IEEE Expert 3(3): 70-77.

Bareiss, R. 1989. Exemplar-Based Knowledge Acquisition. Perspectives in Artificial Intelligence Vol. 2., B. Chandrasekaran, editor. Academic Press, New York. 169 pages.

Berry, J.K. 1993. Forest values: A reflection of society. Pages 63-68 in: Proceedings, 1993 Society of American Foresters National Convention.

Beyerstein, D. 1993. The functions and limitations of professional codes of ethics. Pages 416-425 in: Applied Ethics: A Reader, E.R. Winkler and J.R. Coombs, editors. Blackwell, Oxford, UK.

Bowyer, J.L. 1991. Responsible environmentalism: The ethical features of forest harvest and wood use on a global scale. Forest Perspectives 1(4): 12-14.

Colfer, C.J.P., R. Yost, F. Agus, and S. Evensen. 1989. Expert systems: A possible link from field work to policy in farming systems. AI Applications 3(2): 31-40.

Comett, Z.J., J.E. Force, and S.J. Radcliffe. 1994. SAF's evolving land ethic. Journal of Forestry 92(11): 6-9.

Cortner, H.J., M.A. Shannon, M.G. Wallace, S. Burke, and M.A. Moote. 1996. Institutional barriers and incentives for ecosystem management: A problem analysis. USDA Forest Service General Technical Report PNW-GTR-354. 35p.

Danielson, P.A. 1992. Artificial Morality: Virtuous Robots for Virtual Games. Routledge, London.

Danielson, P.A. 1995. Evolutionary models of cooperative mechanisms: Artificial morality and genetic programming. In: Modeling Rationality, Morality and Evolution, P. Danielson, editor. Vancouver Cognitive Science Series, No. 7, Oxford University Press.

Danielson, P. 1993. Morality, rationality and politics: the greenhouse dilemma. Pages 329-340 in: Applied Ethics: A Reader, E.R. Winkler and J.R. Coombs, editors. Blackwell, Oxford, UK.

Eberle, M, K. Cooke, and T. McDaniels. 1992. Conflict resolution in forestry: Recent initiatives. Canada-British Columbia Partnership Agreement on Forest Resource Development: FRDA II. Report No. 199. Forestry Canada, Victoria, B.C.

Flybjerg, B. 1993. Aristotle, Foucault and progressive phronesis: Outline of an applied ethics of sustainable development. Pages 11-27 in: Applied Ethics: A Reader, E.R. Winkler and J.R. Coombs, editors. Blackwell, Oxford, UK.

Gordon, T.F. 1994. Computational dialectics. Pages 25-36 in: Workshop Kooperative Juristische Informationssysteme, GMD Studien Nr. 241, September 1994.

Greider, T., and L. Garkovich. 1994. Landscapes: The social construction of nature and the environment. Rural Sociology 59(1): 1-24.

Jaggar, A. 1993. Taking consent seriously: Feminist practical ethics and actual moral dialogue. Pages 69-86 in: Applied Ethics: A Reader, E.R. Winkler and J.R. Coombs, editors. Blackwell, Oxford, UK.

Jamieson, D. 1993. Ethics, public policy and global warming. Pages 313-328 in: Applied Ethics: A Reader, E.R. Winkler and J.R. Coombs, editors. Blackwell, Oxford, UK.

Kettner, M. 1993. Ethics and consensus formation in the public domain. Pages 28-45 in: Applied Ethics: A Reader, E.R. Winkler and J.R. Coombs, editors. Blackwell, Oxford, UK.

Leopold, A. 1949. A Sand County Almanac. Oxford University Press, New York.

Prietula, M. 1993. AI and theories of groups and organizations: Conceptual and empirical research. Papers from the 1993 AAAI Workshop, July 11-15, Washington D.C. Technical Report WS-93-03. AAAI Press, Menlo Park, California. 102 p.

Proctor, J.D. 1996. Will the real land ethic please stand up? Journal of Forestry 94(2): 39-43.

Ralston, H. 1993. Environmental ethics: Values in and duties to the natural world. Pages 271-292 in: Applied Ethics: A Reader, E.R. Winkler and J.R. Coombs, editors. Blackwell, Oxford, UK.

Reeves, G.H., D.L. Bottom, and M.H. Brookes. 1992. Ethical questions for resource managers. USDA Forest Service General Technical Report PNW-GTR-288. 39 p.

Robbins, S.P. 1993. Organizational Behavior: Concepts, Controversies, and Applications. 6th edition. Prentice Hall, Englewood Cliffs, New Jersey.

Shindler, B., B. Steel, and P. List. 1996. Public judgments of adaptive management. Journal of Forestry 94(6): 4-12.

Society of American Foresters. 1993. A discussion guide for the SAF Code of Ethics. Society of American Foresters 93-04. 16 pages.

South, D.B. 1994. SAF's public relations ethic. Journal of Forestry 92(11): 7.

Thomson, A.J. 1993. Paradigm green: AI approaches to evaluating the consequences of changing environmental viewpoints. AI Applications 7(4): 61-67.

Thomson, A.J. 1996. Asimov's psychohistory: Vision of the future or present reality? AI Applications 10(3): 1-8.

Thomson, A.J., D.G. Goodenough, B. Adams, R. Archibald, D. Morgan, D. Hawkins, and D. Say. 1996. Landscape management and biodiversity: Automating the design of forest ecosystem networks. AI Applications 10(3): 57-65.

Winkler, E.R., and J.R. Coombs. 1993. Applied Ethics: A Reader. Blackwell, Oxford, UK.