A Biased History of CAAD
The bibliographic version

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Abstract. *The democratization and popularization of the computer has brought on fundamental changes to many areas related to computer science, including CAAD. Such areas have been facing the necessity to reposition and reorient themselves in rapidly evolving academic and professional frameworks. A factor that complicates the processes of repositioning and reorientation is that most areas have a short but varied and frequently incoherent history that may be poorly understood. The paper is an attempt to trace the history of CAAD by means of publications. This refers to both key publications and the thematic structure of the overall CAAD production. The underlying hypothesis is that CAAD derives from two distinct ambitions, the technology-driven, bottom-up development of architectural computer graphics and the more domain theory-minded, top-down automation of designing. A third, less popular ambition is the computerization of analysis and evaluation, which can be treated as a subcategory of the previous two. The results of the bibliographic analysis are summarized in a timeline that indicates a convergence of ambitions and approaches in the 1980s, the period when CAAD became a recognizable area. In the 1990s the democratization and popularization of the computer caused diversification of CAAD activities over a wide spectrum, ranging from support to end-use of computer systems to computational theory and including the development of advanced, specific applications in cooperation with other architecture, building or design specializations.*

Keywords. *History; bibliography; drawing; design; computerization.*

Introduction: tracing patterns

The origin of this paper lies in the bibliographic work every researcher conducts practically daily, searching for precedent projects, identifying related solutions and refreshing knowledge of already explored subjects. Sooner or later several patterns emerge out of the collected information, including tendencies, approaches and principles that have been determining the development of the area. These patterns are seldom accidental or abstractly scientific. Even in long established areas any given period tends to be characterized by specific individuals and groups that maintain complex relationships of cooperation, antagonism and personnel transfers. Meeting these research-

ers and seeing them perform in conferences adds to the understanding of the patterns both in terms of the dynamics of development and at a personal level that helps make explicit background issues such as reasons for transitions.

Recognition of these patterns is especially useful in younger areas like CAAD that have yet to receive sufficient attention in historical studies. Textbooks and similar overviews tend to focus on such patterns in order to provide a complete and coherent presentation of an area. Such a presentation and the insights it supports are valuable in periods of rapid, fundamental change. The democratization and popularization of the computer in the past ten years has brought on such changes to many areas related to computer science, including CAAD. The effect of these changes has been the necessity to reposition and reorient research, teaching and professional activities in ways and directions that may have been unexpected only a few years previously. A factor that complicates the processes of repositioning and reorientation is that areas such as CAAD have a short but varied and even incoherent history that may be poorly understood. This may lead to choices that have little foundation in the character and the potential of the area.

In an attempt to make my own understanding of CAAD more objective I have tried to justify my conclusions on the basis of publications in the area. This does not necessarily remove most biases but provides at least some degree of transparency and a measure of completeness. I must acknowledge the limited scope of my own ideas and offer my deepest apologies to all those who have contributed to the development of CAAD but are not mentioned in the present paper. The omission is not a reflection on the value of their contribution but the result of practical limitations, such as my personal blind spots and the space allocated to this paper.

The bibliographic research has been greatly simplified by CumInCAD (cumincad.scix.net: Jun 2005). In its current state this is already the definite repository of so-called grey literature in CAAD and provides a comprehensive basis for meta-analyses, despite a number of limitations and problems (Martens, 2004; Martens and Turk, 2003). In the case of the present paper CumInCAD has been used as the main source for tracing the history of CAAD by means of publications:

1. Through key publications in CAAD, such as books providing an overview of the area or articles initiating a research subject.

2. By the attention paid to specific subjects, as indicated by the number of corresponding publications in key journals and conference proceedings.

3. The thematic composition of main publications.

The results of these analyses have been considered against the hypothesis that CAAD derives from two distinct ambitions:

1. Architectural computer graphics: this is technologically oriented and addresses primarily practical issues in a generally bottom-up manner

2. Generative architectural systems: various attempts to automate the production of architectural designs, normally in a top-down fashion and on the basis of rules that demarcate a microworld of style or application area.

A third, less popular ambition is the automation of analysis and evaluation. On the basis of its volume, significance and methodical affinity most approaches to design and building analysis form a distinct subcategory under generative systems: in many cases analysis can be seen a reversal of generative procedures, with the same principles and techniques (Koutamanis, 2000). In a number of other cases, analysis and evaluation fall under visualization and simulation and hence computer graphics.

A timeline for CAAD

The history of CAAD is thankfully short. Most

researchers considered to be founding fathers of the area are still active and many others have been associated with the area for most of its existence. The first steps took place in the 1960s, under the influence of modernist thinking and in relation to technological explorations. CumInCAD appears to agree with this, as it contains only one publication prior to 1960. In terms of decades (an unscientific but handy subdivision) the contents of CumInCAD are:

Table 1. CAAD publications in CumInCAD by decade.

Decade	Number of publications in CumInCAD
1960s	16
1970s	185
1980s	984
1990s	3,226
2000s	2,723

These numbers reveal just that CAAD established effective mechanisms for the production of publications in the 1990s, a decade generally characterized by an explosive growth in the number of scientific publications. This growth appears to continue: the first half of the current decade has been almost as productive as the 1990s. The numbers also reflect the availability of material for CumInCAD, i.e. that most digital publications that could be directly included date back to the mid-1990s. However, despite any reservations one might have about these numbers, it is evident from the huge difference in production from the 1960s and 1970s that the 1980s were the period when CAAD became established and acknowledged, to a large degree on the basis of work done in the 1970s.

A closer look at the publications of the 1960s returns four main groups. The first is work on the technological development of design computing. This group includes Ivan Sutherland's work on Sketchpad (Sutherland, 1963), widely credited as the turning point for computer graphics and CAD. The second group consists of publications on the architectural application of such technolo-

gies. A third group comprises references to other, related areas such as artificial intelligence, which provided methods and techniques also applicable to architectural design. The final group refers to similar methodical and theoretical work in the architectural domain. Strictly speaking this group is represented by a single but influential publication (Alexander, 1964). The absence of similar, generally equally influential publications from the same period arguably reveals the strong preference for domain solutions in CAAD (as opposed to domain analyses).

Research in the 1960s appears to deal with the technological foundations of CAAD, as well as justifications, references and inspirations for the area, including from sources outside architecture and building. The technological foundations focus on the development of computer graphic systems not only for interactively drawing in the computer but also with respect to design problems that require advanced, computational representations (Shaviv and Greenberg, 1968). While such implementation issues are becoming well-established, design automation is still clearly under development.

The grouping of publications in the 1970s is essentially the same as in the 1960s. There is extensive coverage of computer graphics, which has become an acknowledged independent area and exerts significant influence on CAAD, primarily through the early CAD systems. These systems represent a turning point, as the first holistic cases of technology transfer: they are adopted (and occasionally adapted) by a CAAD as a complete solution to the computerization of architecture. The euphoria produced by the transfer does not last long, as CAAD realizes the limited scope of general-purpose CAD systems and, through the distinction between design and drawing, restricts them to implementation tasks.

The interest of CAAD in related areas and in particular artificial intelligence remains strong in the 1970s. The promise of human-like intelligence and even better performance is inspiring and early

demonstrations support an optimistic view, to the extent of considering replacing the designer with a machine (Negroponte, 1975). Such ideas are not unique to CAAD. The notion of designing without architects is also popular in other areas of the same time, e.g. participatory design.

Probably the most striking characteristic of the 1970s is the consolidation of CAAD theory and methods. The production of the first PhD dissertations in CAAD (Yessios, 1973; Akin, 1979) and the first overviews of the area (March and Steadman, 1971; Eastman, 1975; Mitchell, 1977) present insightful and comprehensive information on the ambitions and means of CAAD. As the availability of introductory texts and related research increases, the area attracts more attention and activity. The most important consequence of the new conditions is the development of different approaches to the automation of designing. Generative systems such as space allocation techniques, shape grammars and rectangular arrangements become known and popular subjects for CAAD research in the 1970s. Interestingly, there is little cross-pollination between these classes of generative systems. Nevertheless, overviews of the area promote the idea of a recognizable CAAD field, even if this means little more than the enumeration of systems and approaches that are being developed at the time.

In the 1980s CAAD becomes a recognizable area. Through the convergence of different approaches, techniques and ambitions CAAD appears to form a coherent and comprehensive structure that covers all parts, aspects, stages and specializations in architectural design and building construction. The intention to handle all kinds of problems, from making a simple line drawing to explaining and supporting the use of design precedents, on the basis of the same methodical principles helps promote CAAD in academic education and research, as well as gain some acceptance in practice. Unfortunately, these principles tend to become quite lofty, probably also in order to avoid too close associations with mundane, practical aspects (Kvan, 2004). The axiomatic dismissal of drawing as a trivial, passive activity by the majority in CAAD (at a time when philosophers and cognitive scientists rediscover images as a direct source of information and knowledge) is one of the excesses of the period. The same loftiness stimulates the development of prescriptive approaches, with rather detrimental effects on computational
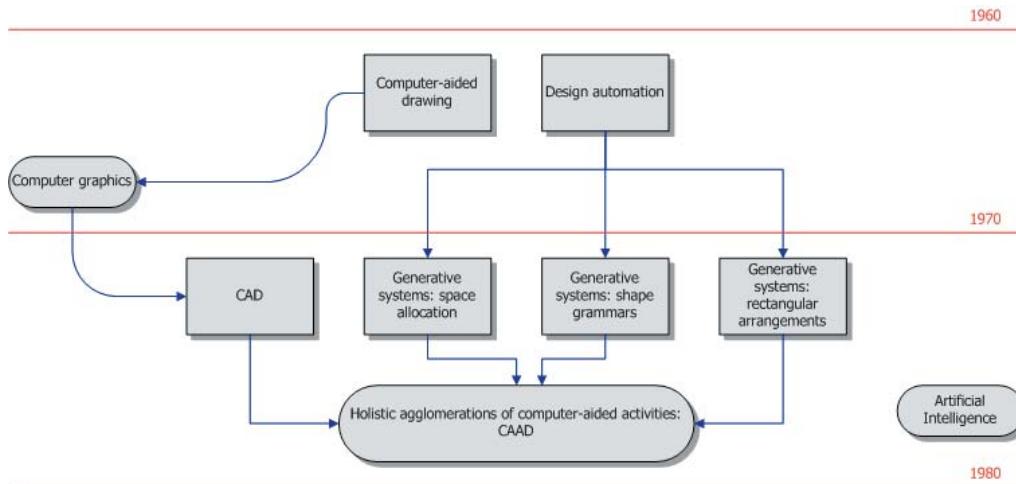

Figure 1. Timeline 1960-1980

design analysis, which was forced toward a normative direction rather than remaining closer to the descriptive developments in computer science (e.g. simulation).

Despite such problems, the convergence stage seems to have been a very fruitful and stimulating period, especially because of the correlation of the two main ambitions of CAAD. The main effect of this correlation is that different approaches, abstraction levels or aspects become at least much better informed with respect to the whole spectrum of goals and tools. For example, generative theorists appear to become more knowledgeable about practical issues in representing a design and computer drafting teachers are able to use elements from CAAD theory in order to explain and justify practical choices. The legacy of this convergence is still visible in CAAD education: CAAD components are usually easy to integrate in studio activities, while CAAD courses can develop in several directions, e.g. electronic design studios. The convergence and consolidation of activities, as well as the increasing scientific significance of computing in the 1980s allow the development of
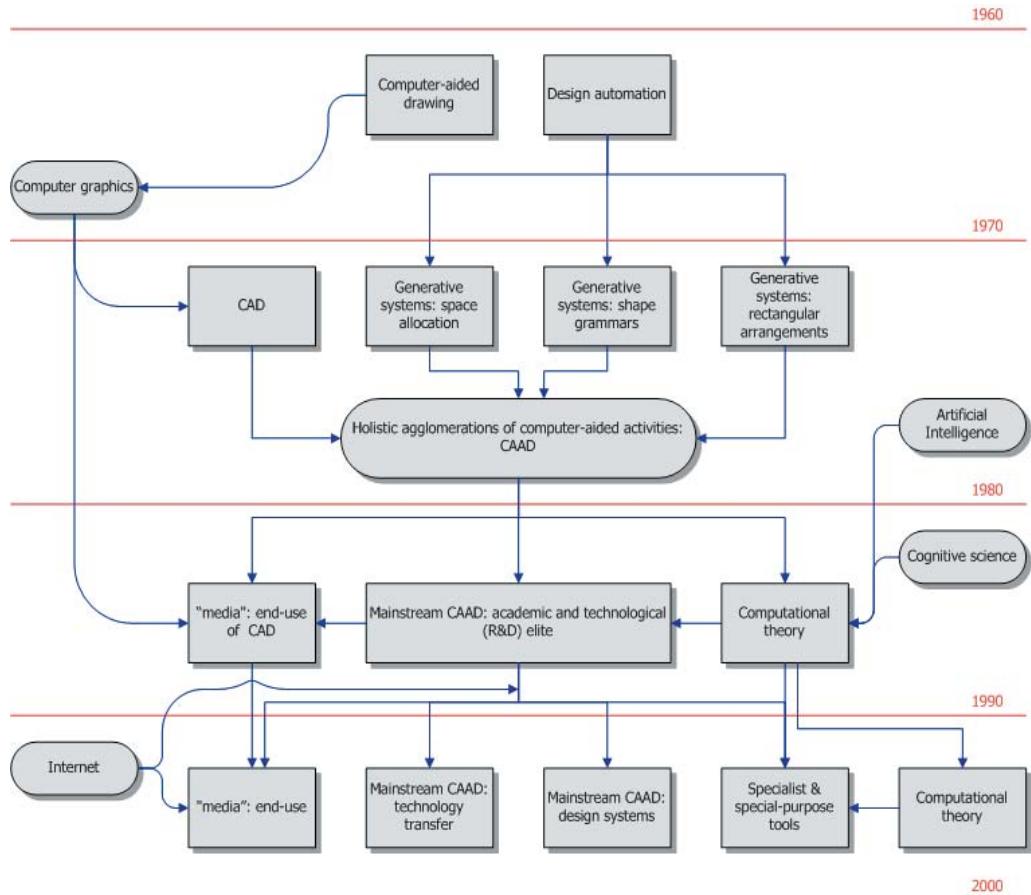

Figure 2. Timeline 1960-2000

a mainstream in CAAD. Despite the abundance of bandwagons (mostly new technologies), the thematic structure of conference proceedings remains quite stable. The same applies to the production of publications within this structure.

A particular characteristic of the period is that theoretical studies of architecture and designing become more detached from the mainstream in CAAD while remaining firmly within the field. This is probably partly because CAAD as an established area is less needy of unconditional support and can tolerate different views and partly because the applications covered by the mainstream provide insufficient coverage for the subjects that concern theoretical studies. With respect to the three levels proposed by Marr (1982), mainstream CAAD focuses mainly on the implementation and algorithmic levels, while the development of computational theory does not necessarily lead to concrete applications.

The 1990s start quite optimistically. CAAD is an established area, with its own conferences, journals and almost exclusive rights (in architecture and building) to an expensive and promising technology. Computer use in designing, even mere drafting, is not widely accepted yet (e.g. in architectural studios) but is becoming increasingly popular with students and in practice. Frequently this popularity relates to practical aspects (primarily efficiency improvements) or new media (e.g. animations or the Internet) rather than the intellectual potential of CAAD theory. However, this does not deter CAAD that gladly accommodates new technologies and subjects in teaching and research. Many publications in the 1990s describe the use of commercially available software, often from a critical, creative viewpoint but nevertheless at the level of an informed end user. This level invites competition in various forms (also in academia) but invariably concerned with the mere application of commercially available programs, generally under the term "(digital) media". Their guiding principles can be found in user manuals and in user experience

rather than CAAD theory.

The democratization of the computer brings the convergence phase to a rather abrupt end. In the second half of the 1990s computer technologies begin to become less expensive, widespread and widely accepted in architectural education and practice. Popular perception of computing changes from a more or less anorak subject to a general skill and an accessible infrastructure for non-professional applications, in particular entertainment. Such applications lead to a broad increase in skills and to a different type of acceptance. Moving from here to professional applications is a predictable extension. As a result, computerization in architectural practice in the late 1990s owes more to general social and technological developments than to work done in CAAD. This also means that the influence of CAAD on the developments in practice is limited. Most early instances of computerization in practice in this phase are simple, straightforward transfers of analogue and manual processes to the computer (along the "media" line). The theoretical and methodical knowledge developed in CAAD is only sporadically utilized in such transfers. As applications become more sophisticated, knowledge of CAAD becomes incrementally more important, but still restricted to practical matters, i.e. mainly for its experiential value.

The reaction to the changing context in CAAD is initially one of surprise and self-doubt. It seems lead to a discussion that never happens (e.g. at eCAADe 1996 in Lund, in my personal experience). When acceptance settles in, the reaction becomes twofold: on the one hand CAAD accepts a supporting role in the new, digitally minded architectural education (thereby reinforcing "media"), while on the other CAAD research focuses on small, technologically advanced and sometimes esoteric subjects. This leads to two main tendencies within mainstream CAAD (Tweed and Carabine, 1999). The first is characterized by a preoccupation with technology transfer and leads to early adoption of new, promising developments but not always
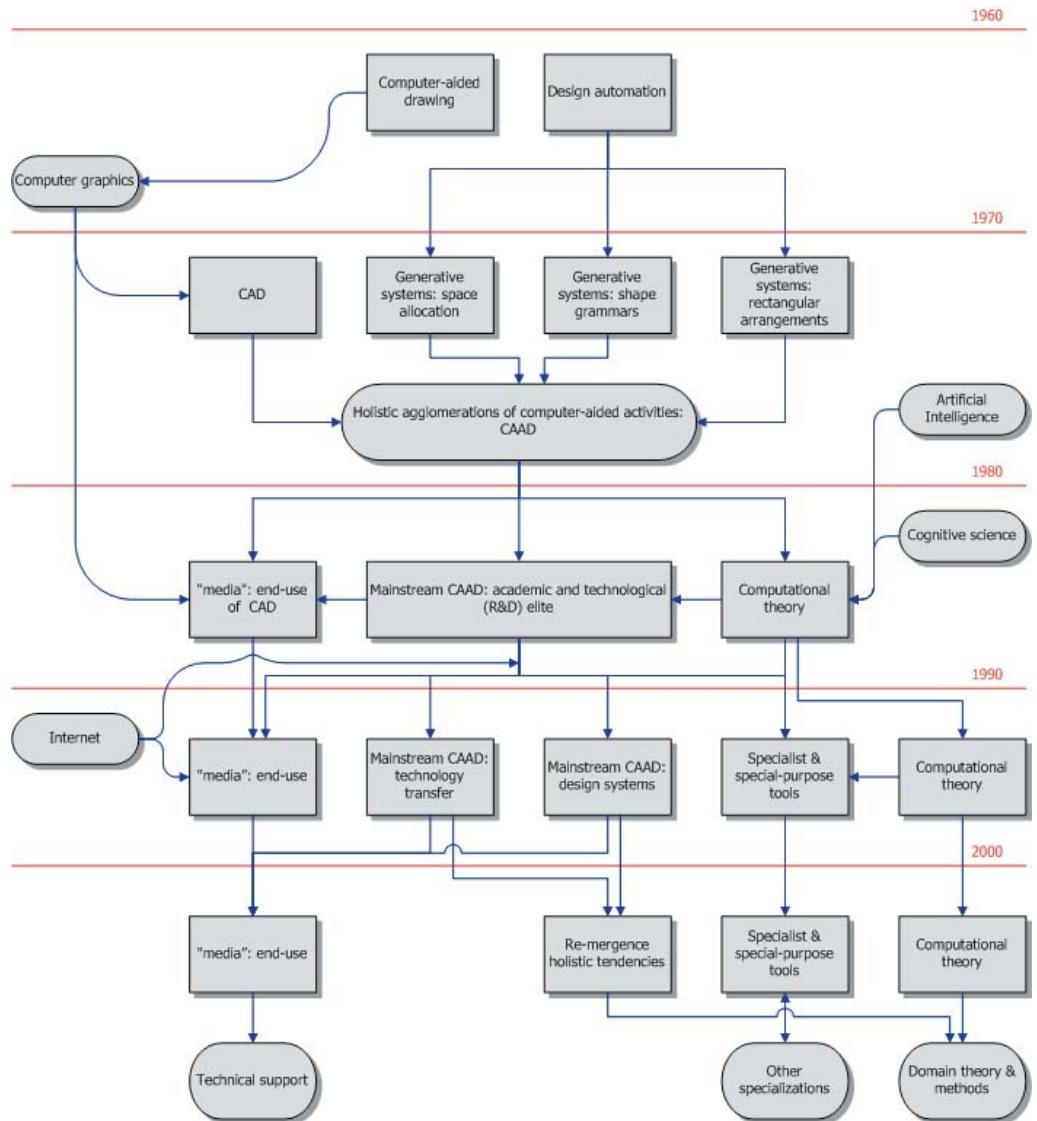
Figure 3. Timeline 1960-2005

thorough analyses of applicability, relevance and feasibility. CAAD production in the 1990s is riddled with bandwagons much more than in the 1980s. The second tendency attempts to retain the holistic character of the area by clearer demarcations and increased coherence between the theoretic, algorithmic and implementation levels (Marr, 1982). The products of this tendency are systematic structures (design systems), usually restricted to specific design situations (Hsu and Krawczyk, 2003). In my opinion, most systems developed for design collaboration belong to this tendency.

As a result of this dichotomy in mainstream CAAD, computational theory is able to retain its semi-independent status and even connect with practice, architectural criticism and "media" (e.g. with respect to free-form architecture). In addition to that, there is a limited migration from CAAD in the direction of highly specialized disciplines where computerization provides direct solutions to questions of performance, productivity and efficiency. This leads to a fairly large number of specialist and special-purpose tools, frequently developed in collaboration with domain experts. These tools have strong relationships with computer-mediated analysis and evaluation (Maver, 1987).

Future developments

At all levels in my education I was told that history is important because learning about the past is useful for the future. History should provide insights into the causes of current phenomena. History is also supposed to repeat itself, even though these repetitions can be far from self-evident. Learning from the past does not imply that we should consider CAAD as other than a temporary area, developed in response to short-term problems. A pessimistic view is that CAAD it is still alive simply because it has managed to establish itself as a scientific area with structures such as conferences and journals that preserve it. However, it is probably more important that the subjects that led to the emergence of CAAD remain within the architectural domain, whatever the name of the specializations that treat them.

Judging from recent developments (i.e. the 2000s), it appears that CAAD is trying to re-establish itself as an integral scientific area, more concerned with architecture and design than technology transfer. Domain theories are becoming more important than the technologies used to implement them. This also supports computer-related developments within or in relation to other specializations and may lead to the absorption of parts of CAAD by such specializations. This should not be frowned upon, provided that these specializations can offers sufficient scope and support to the subjects of CAAD. Similarly, computational theory is becoming a flavour of architectural and design theory and consequently grows in stature and audience.

In addition to these generally positive developments, there also emerges an unholy alliance between end-use facilitators from both CAAD and technical support. The reduction of CAAD into "digital media" and the servicing of commercially available systems may seem a pragmatic choice under difficult conditions but also implies the lack of added value in the production of CAAD in the last forty years. The real question is why CAAD may have failed to convince.

Judging from recent developments CAAD is an area still changing in response to external conditions. Whether the area has run its course or not is yet unclear. On the other hand, it is clear that the last decade has been more concerned with survival as CAAD failed to profit from the democratization of the computer. Established lines continue to be strong but influences from other areas and new ideas from the architectural domain appear too slow and too limited to add to the existing subjects. Moreover, there is substantial competition from other areas that expand in the direction of computerization with the same ease that CAAD has been proposing solutions for specialist problems.

Probably the biggest compensation for the troubles of the area is the quality regularly achieved by CAAD practitioners. It gratifying that there has been a steady production of critical, advanced publications that go far beyond mere propaganda or indifferent reports on yet another experiment that creates feelings of déjà vu. Such quality suggests that these publications can have a positive impact on both the area itself and architecture in general.

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