

Chapter 2

Self-awareness and Self-expression: Inspiration from Psychology

Peter R. Lewis, Arjun Chandra, and Kyrre Glette

Abstract Self-awareness concepts from psychology are inspiring new approaches for engineering computing systems which operate in complex dynamic environments. There has been a broad and long-standing interest in self-awareness for computing, but only recently has a systematic understanding of self-awareness and how it can be used and evaluated been developed. In this chapter, we take inspiration from human self-awareness to develop new notions of computational self-awareness and self-expression. We translate concepts from psychology to the domain of computing, introducing key ideas in self-aware computing. In doing so, this chapter therefore paves the way for subsequent work in this book.

2.1 Introduction to Self-awareness

The *Oxford English Dictionary* defines *awareness* as “knowledge or perception of a situation or fact.” Informally, we might typically consider that humans build up knowledge, or become aware of things, by perceiving the world around them. We observe interactions, listen to other people, watch television, read books, and, particularly in early life, learn through play. When considering awareness in humans, it is common to consider that all the knowledge we possess, all of our awareness, is acquired through perception. This idea was first postulated by Hume [187], who argued that all human knowledge is induced from experience. What then does it mean for a human to be *self-aware*? For Hume, the “self” is not a defined physical entity, but instead describes the bundle of experiences or perceptions unique to an

Peter Lewis
Aston University, UK, e-mail: p.lewis@aston.ac.uk

Arjun Chandra
Studix, Norway, e-mail: arjun@studix.com

Kyrre Glette
University of Oslo, Norway, e-mail: kyrrehg@ifi.uio.no

individual. A Humean form of self-awareness might then be considered to consist of an individual's knowledge of its experiences. Kant [210] criticised Hume's view, extending the scope of the self significantly, arguing that there is some entity which is the subject of these experiences, and is common through space and time. This Kantian self synthesises information from experiences with concepts held in the mind and with the imagination. Kant further argued that as an individual performs actions within the world, since its actions are based on its synthesised knowledge, they represent its self, giving rise to the self also as an object. This object in turn is something which can be perceived and experienced.

Though there is a long history of analysis of the nature of the self in philosophy, more recently, psychology has made a more pragmatic attempt to develop an understanding of the varieties of knowledge individuals possess concerning themselves. The notion of self-awareness first appears in the literature around the turn of the twentieth century [25, 382], perhaps most importantly with James [197] making the distinction between two forms of self based on the differences between the Humean and Kantian views described above. First, the *implicit* self, often referred to as the self-as-subject, or the "I", is the self which is the subject of experiences. These experiences are unique to the individual, and they are from the individual's own point of view, determined by factors such as their sensing apparatus, their situation within the world, and other factors associated with their own state. Second, the *explicit* self, or self-as-object, can be discerned. Here the self is an object of knowledge. It is a thing which can be recognised, modelled and reasoned about, including in relation to other objects in the world. An individual's awareness of its explicit self is often considered the more advanced form of self-awareness in this distinction, building on implicit self-awareness. Indeed, implicit self-awareness emerges much earlier in the lives of human infants than its explicit counterpart does [231].

One commonly considered form of self-awareness is that as measured by the so-called *mirror test* [140]. A subject being evaluated is presented with a mirror, to which it is then allowed to get accustomed. The subject is then distracted and, without its knowledge, a visible change is made to its appearance. This is usually done by marking its face, e.g., putting a spot on its cheek or forehead. The subject is then presented with the mirror again. Any behaviour directed towards this marker by the subject implies self-recognition, which is seen as being enabled by a mental representation of oneself (also known as a secondary representation). As Asendorpf et al. [18] put it:

"[secondary representation] is not a perception of oneself but rather a constructed mental model of oneself that can be manipulated in fantasy. Therefore, the ability to recognise oneself in a mirror that requires linking a mirror image (a primary representation) with one's self marks the capacity for secondary representation."

Explicit self-awareness requires a subject to possess the capacity to construct such a secondary conceptual representation of itself. What then does the mirror test tell us about self-awareness? Humans, primates and some other animals have "passed" the mirror test [140, 18], however, Haikonen [155] showed that very little sophistication in computing machinery can enable a computational system with visual sensors to also pass. Haikonen therefore goes on to suggest that the ability or

inability to self-recognise may not prove the presence or absence of self-awareness more generally at all. Since a computing system can specifically and easily be designed to pass the mirror test, using the test as a yardstick by which to tell whether or not the system is self-aware may thus be a misleading notion. Indeed, even if we accept Asendorpf's [18] claim that self-recognition requires some form of secondary representation (i.e., a conceptual model) of oneself, it is clear that the mirror test is concerned with a quite specific aspect of what might be considered self-awareness, based on a conceptual model of one's appearance. As this chapter will go on to discuss, we are concerned in this book with a broader treatment of self-awareness.

As should now be apparent, and is highlighted in recent work (e.g., by Morin [275], Legrain et al. [231] and Rochat [344]), there is much ongoing discussion about what might and what might not constitute self-awareness and various observed forms of it. In some cases, more "primitive" aspects of self-awareness are stated to fall instead into consciousness, upon which self-awareness builds. For example, Morin's definition considers self-awareness as distinct from, but building upon consciousness, as "*the capacity to become the object of one's own attention.*" Further, he also addresses the conceptualisation of subjective experience, describing a self-aware organism as one that "*becomes aware that it is awake and actually experiencing specific mental events.*"

In other cases, this perceptual (or pre-conceptual) subjective experience is itself also included in the scope, effectively presenting self-awareness and consciousness as overlapping concepts. In this chapter, our concern is not with attempting to settle these debates, but instead with understanding theories of self-awareness as presented in the literature, with the aim of developing concepts inspired by self-awareness to benefit the design of computing systems. Therefore, some of what is presented and discussed here is considered by some literature, but not all, to be forms of consciousness rather than self-awareness proper.

2.2 Key Concepts for Self-aware Systems

In drawing inspiration from psychology, in this book we utilise three key concepts which appear prominently in the self-awareness literature, and which have shown promise as useful concepts in the design of self-aware computing systems. These three key concepts are (i) public and private self-awareness, (ii) the extent of self-awareness capabilities can be characterised by various levels, and (iii) self-awareness can be a property of collective systems, where knowledge need not be present in a single central source, and may instead be distributed. Further, we argue that self-awareness properties alone are of limited value in computational systems, or indeed any system at all, unless accompanied by associated behaviour. In this book we use the term *self-expression* to refer to *behaviour based on self-awareness*. The remainder of this section introduces these key concepts.

2.2.1 *Public and Private Self-awareness*

As discussed above, Morin's definitional introduction to self-awareness contains two aspects. His first is centred on the idea of being the "*object of one's own attention*", and establishes a subject-object view of self-awareness, where aspects of oneself are objects within a conceptual mental model. This *explicit* self-awareness (as presented, e.g., by Legrain et al. [231]) permits an individual to focus its attention on itself, to consider itself as an object within the world, and to observe and consider its own behaviour. However, Morin's second passage, that the individual "*becomes aware that it is awake and actually experiencing specific mental events*" reveals another facet of self-awareness, that which is *implicit*. This is concerned not with the self-as-object "me", but rather with "I", the self-as-subject of experiences. Here, the individual is aware of its experiences within the world, and that these are its own experiences, subjective and unique.

This distinction was first expounded in detail by Duval [111], who defined two classes of self-awareness: *subjective* and *objective*. Objective self-awareness is described as being "*focused exclusively upon the self and consequently the individual attends to his conscious state, his personal history, his body, or any other personal aspects of himself*" [111]. Subjective self-awareness by contrast is described as "*a state of consciousness in which attention is focused on events external to the individual's consciousness, personal history, or body*" [111].

Many authors have since developed this distinction further [131, 55, 58, 137, 147], in whose literature a slightly different distinction between *public* and *private* self-awareness develops. Private self-awareness is concerned with obtaining knowledge of internal phenomena, typically externally unobservable and accessible only to the individual. Such knowledge might include, for example, being hungry or having a headache. More complex private self-awareness might include an individual's knowledge of its values, opinions, goals or thought processes. Public self-awareness, on the other hand, is more concerned with how the individual can be (or is) perceived externally. This might include knowledge of how the individual appears to others, its social relationships or the effects of its interactions with the physical environment. Froming et al. [137] describe this as awareness of oneself as a *social object*.

In a minimal form, we may consider public self-awareness only insofar as it is present in individuals capable of implicit (or subjective) self-awareness. In this case, the individual would be capable of subjective perception of its environment. Given the unique situated nature of the individual, these experiences are themselves uniquely related to itself. However, in an explicit (or objective) form, public self-awareness may include knowledge of how the individual itself is or could be perceived by others, for example, how it looks (recalling the mirror test discussed above), whether it is a member of a particular group, or whether it has impacted on a shared environment. This requires knowledge not only of its environment, but also of itself as an object within that environment, an object of which others may be aware.

In summary, an individual's public self-awareness is concerned with knowledge obtained from experiences of the perceived environment in which the individual is

situated. This knowledge may include both social aspects (e.g., other individuals, its own appearance) and purely physical aspects (e.g., the world). An individual's private self-awareness is by contrast concerned with knowledge obtained by experiences solely concerning the individual. This knowledge is obtained internally and is typically not available to others, unless the individual communicates it. An individual which is self-aware in both the public and private senses therefore has the capability to acquire and possess knowledge of its external environment and its internal state.

In taking inspiration from self-awareness for computing systems, we could choose (and some have previously chosen) to consider self-awareness only in its explicit, private sense, as the ability to build conceptual models of (part of) its own internals. Alternatively, we can broaden this further, to include the consideration that a system's sensing of its environment and itself provides a unique subjective experience, which can be modelled and reasoned about. Regardless of how we choose to draw the boundary around a definition of self-awareness, the literature does agree that self-awareness even within both its implicit and explicit forms is a multi-level phenomenon, where increasingly complex levels describe an individual's self-awareness capabilities.

In considering the self-awareness capabilities of systems in general and computing systems in particular, we are interested in the benefits (or not) of increased self-awareness, relative to current state-of-the-art systems. For example, to what extent can endowing a system with conceptual models of itself, its interactions, its goals, its past and its future enable more effective self-expression? Can this provide increased potential for adaptation? How important is a system's ability to learn such models for itself? What are the costs of maintaining and learning such models? And can a self-aware system build models of these costs too, taking account of them when deciding how to best conceptualise itself and its world? On the implicit side, what are the benefits of considering the subjective nature of a system's sensory input? To what extent does the consideration of a system's own state affect how that input is collected, stored, and reasoned about? Is there a benefit to considering differences between systems' own subjective experiences of a shared environment, or does this simply add complexity to a system's description, for little gain? These questions give a flavour of the reasons why, in this book, we take a broad view of self-awareness, including both implicit and explicit, and public and private forms. The chapters throughout the book engage with different aspects of self-awareness, from runtime learning and trade-off modelling, to exploring the heterogeneity of different systems' sensed experiences in a shared problem domain.

2.2.2 Levels of Self-awareness

As noted in much of the self-awareness literature (e.g., [231, 275]), it is widely believed that self-awareness is not a singular, *all or nothing* phenomenon, rather it can be thought of as a spectrum, where the capabilities of an individual are associated

with one or more levels of self-awareness. Accordingly, several attempts have been made to define levels of self-awareness. Morin [275] provides a review of several of these classifications, highlighting similarities and differences between them. Some sets of levels, such as those by Rochat [344], focus on classifying self-awareness capabilities according to the way in which they are observed to develop in human children. Legrain et al. [231] provide a classification of three levels, considering only explicit self-awareness. One classification, due to Neisser [284], describes five levels which offer what is perhaps one of the most broad treatments of self-awareness, from the most minimal to the most advanced. Importantly from our perspective, Neisser's model also includes aspects of implicit self-awareness. In line with our approach of taking a broad view of self-awareness in our mission to translate concepts from psychology to computing, we have focussed on Neisser's levels as a concrete source of inspiration. These five levels now follow.

1. **Ecological self**

The ecological self is the most minimal form of self-awareness. It permits sufficient knowledge only for basic stimulus-response behaviour, as the individual has a basic awareness of stimuli. The ecological self can be thought of as the minimum requirement for the individual to not be unconscious.

2. **Interpersonal self**

The interpersonal self enables the individual to possess a simple awareness of its external interactions, permitting limited adaptation to others in the performance of tasks.

3. **Extended self**

The extended self extends the interpersonal self to permit reflection of interactions over time. The individual is aware of the existence of past and future interactions.

4. **Private self**

The private self allows the individual to process more advanced information concerning itself, such as thoughts, feelings and intentions.

5. **Conceptual self**

The conceptual self, or self-concept, is the most advanced form of self-awareness, representing that the individual is capable of constructing and reasoning about an abstract representation of itself.

This final, most advanced level of self-awareness also permits what is sometimes termed **meta-self-awareness** [276, 366]. This is an awareness on the part of the individual that it is itself self-aware. Meta-self-awareness may consist of complex analysis and reasoning of both public and private self-awareness processes at any of the preceding levels. Examples of meta-self-awareness might include the individual's being aware that it is angry about something, or that it has recently learnt a lot about a particular topic. Smallwood et al. [366] discuss awareness at the meta level extensively, arguing that a lack of such a capability can lead to excessive mind-wandering in humans. They argue that the absence of meta level awareness leads to an individual being unable to direct its attention, thus exhibiting a lack of awareness more generally.

2.2.3 *Self-awareness in Collective Systems*

So far, we have just considered self-awareness in the context of a single individual. However, Mitchell [272] notes that self-awareness can also be observed in collective systems, where there is no central point at which such self-knowledge is located. Examples of these collective systems include those comprised of individuals that might normally be considered either organisms in their own right (e.g., ants in a colony) or constituent cells of a larger organism (e.g., neurons in the brain). In these cases, it appears from an external perspective that such biological collective systems are self-aware at the level of the collective, even though this property may not be present at the level of the individual component. This awareness, Mitchell describes as being concerned with

*“information about the global state of the system, which feeds back to adaptively control the actions of the system’s low-level components. This **information about the global state is distributed** and statistical in nature, and thus is difficult for observers to tease out. However, the system’s components are able, collectively, to use this information in such a way that **the entire system appears** to have a coherent and useful sense of its own state.” [272]*

We have added the emphasis here, in order to highlight that a system which behaves as if it were self-aware is not necessarily required to possess a single “mind-like” component¹. Indeed, in many cases, the entire system appears self-aware, despite only local knowledge being present at constituent parts of the collective. Self-awareness might be considered the product of emergence.

This is a key observation which can contribute to the design of self-aware systems: one need not require that such a system possess a global omniscient controller. Indeed, many natural systems appear to have been favoured by evolution which do not have such a central point of control, and rely upon relevant knowledge being available at appropriate locations within the system. It is highly likely that this idea can improve the robustness and adaptability of such systems; these are desirable properties for natural and artificial systems alike.

2.2.4 *Self-expression*

As we have seen, self-awareness is concerned with knowledge synthesised and held by an individual about itself and its experiences. This knowledge may be centrally held, or else distributed in nature. However, in studying the self-awareness properties of natural and computational systems, we have found it advantageous to explicitly and separately consider the related process of an individual determining its behaviour as a result of this knowledge. This process we call self-expression. In

¹ Indeed, while the brain has long been known to be a collective system composed of neurons, consciousness in the human mind is itself thought by some [98] to also be a distributed phenomenon, with nothing like what we might call global knowledge.

social psychology, self-expression has been defined as “*the assertion of one’s individual traits*” [217]. Similarly, Chen et al. [66] define self-expressive individuals as ones which behave “*in line with their states and traits,*” where a trait is “*a genetically determined characteristic or condition*”,² which may be either physical or behavioural.

In this book, we therefore distinguish between self-awareness, which is the property concerned with an individual’s knowledge, and self-expression, which is the property concerned with an individual’s resulting behaviour, behaviour based on or informed by its knowledge and characteristics. This also helps to highlight that action or behaviour is not a requirement for self-awareness. It is, however, typically highly useful, especially in purposeful systems such as those which are engineered. For this reason, we typically consider self-awareness and self-expression together.

2.3 Computational Self-awareness

In this section, we propose that human self-awareness can serve as a source of inspiration for a new notion of *computational self-awareness* and associated *self-expression*. We introduce a general framework for the description of the self-awareness properties of computing systems. In later chapters of this book, this framework is developed into a reference architecture (Chapter 4) and a series of derived architectural patterns (Chapter 5). Together, these can be used to determine whether, how, and to what extent to build self-awareness capabilities into a system. This framework provides a common, principled basis on which researchers and practitioners can structure their work, and indeed is used throughout this book. The psychological foundations, while not strictly necessary, can provide a means of channelling a wide range of ideas – which would perhaps otherwise not have occurred to engineers – acting to inspire the design of future computing systems.

While the concepts of public and private self-awareness transfer in a fairly straightforward manner to computing systems, Neisser’s [284] five levels of self-awareness lend themselves to being easily misinterpreted if discussed only in their psychological context. Therefore, we have found it useful to make these psychological concepts tangible from an engineering perspective. We do this by expressing these concepts in computational terms or processes, as part of our proposed notion of computational self-awareness.

2.3.1 Private and Public Computational Self-awareness

The first key idea of public and private self-awareness can be summarised as follows:

² *American Heritage Science Dictionary*, Houghton Mifflin Harcourt, 2005

- **Private self-awareness:** This is a system's ability to obtain knowledge based on phenomena that are internal to itself. A system needs internal sensors to achieve this.
- **Public self-awareness:** This is a system's ability to obtain knowledge based on phenomena external to itself. Such knowledge depends on how the system itself senses/observes/measures aspects of the environment it is situated in, and includes knowledge of its situation and context, as well as (potential) impact and role within its environment.

Some prior work in self-aware computing has considered only private self-awareness, i.e., a system's awareness of its own internal state. However, the importance of the availability of external sources of information to self-awareness processes should be emphasised: self-awareness is not only concerned with sources of information internal to the individual. We argue that a full consideration of computational self-awareness also includes public aspects, where a system's knowledge of itself in relation to its social and physical environment can be synthesised with private self-awareness, in order to produce integrated conceptual models. In this book, we hope to demonstrate that the distinction, inclusion and synthesis of both public and private self-awareness raise many important questions for engineers of self-aware computing systems.

2.3.2 Levels of Computational Self-awareness

We now describe our computational framing of the levels of self-awareness, which were first presented by Faniyi et al. [127] and elaborated upon by Lewis et al. [236]. It is possible to relate the levels of self-awareness to the concepts of private and public self-awareness, and hence the sources of the relevant knowledge (i.e., based on internal or external sensors). The relevance of each level to these concepts is also described. The relationship provides an indication of the architecture that will be required in order to realise each of the levels. In each case, Neisser's level of self-awareness is given on the left, and our corresponding level of computational self-awareness is on the right.

1. **Ecological self** → **Stimulus-aware**

A system is stimulus-aware if it is able to obtain knowledge of stimuli acting upon it, enabling the ability to respond to events. It does not have knowledge of past/future stimuli. Since stimuli may originate both internally and externally, stimulus-awareness can be **private**, **public** or **both**.

2. **Interpersonal self** → **Interaction-aware**

A system is interaction-aware if it can obtain knowledge that stimuli and its own actions constitute interactions with other systems and the environment. It is able to obtain knowledge via feedback loops that its actions can provoke or cause

specific reactions from the social or physical environment. Simple interaction-awareness may just enable a system to reason about individual interactions. More advanced interaction-awareness may involve the system obtaining knowledge of social structures such as communities or network topology. Interaction-awareness is typically based on external phenomena, whereby it is a form of **public** self-awareness. However, a system which learns about causality in internal interactions with itself would constitute a form of **private** self-awareness.

3. **Extended self** → **Time-aware**

A system is time-aware if it can obtain knowledge of historical and/or likely future phenomena. Implementing time-awareness may involve the system using explicit memory, time series modelling and/or anticipation. Since time-awareness can apply to both internal and external phenomena, it can be **private**, **public** or **both**.

4. **Private self** → **Goal-aware**

A system is goal-aware if it can obtain knowledge of current goals, objectives, preferences and constraints. It is important to note the difference between goals existing implicitly in the design of a system, and the system having access to its goals such that it can reason about or manipulate them. The former does not describe goal-awareness; the latter does. Example implementations of goal-awareness include state-based goals (i.e., knowing what may or may not be a goal state) and utility-based goals (i.e., ability to obtain a utility or objective function). Goal-awareness permits adaptation to changes in goals. When coupled with interaction-awareness or time-awareness, goal-awareness permits the ability to reason about goals in relation to other individuals or likely future goals, respectively. Since goals may exist privately to the system, or collectively as a shared or externally imposed goal, goal-awareness can be **private**, **public** or **both**.

5. **Conceptual self** → **Meta-self-aware**

A system is meta-self-aware if it is able to obtain knowledge of its own level(s) of awareness and how the level(s) are exercised. Such awareness permits meta-cognitive processes [84] to reason about the benefits and costs of maintaining a certain level of awareness. It further allows the system to adapt the way in which the levels of self-awareness are realised (e.g., by changing algorithms realising the levels), thus changing the degree of complexity of realisation of the levels). Since meta-self-awareness is concerned only with knowledge of internal processes, it is a form of **private** self-awareness.

Figure 2.1 shows an illustration of the relationship between private and public self-awareness concepts and these levels.

Although possession of (self-)knowledge is important to achieve computational self-awareness, we argue that it is the *ability to obtain this knowledge on an ongoing*

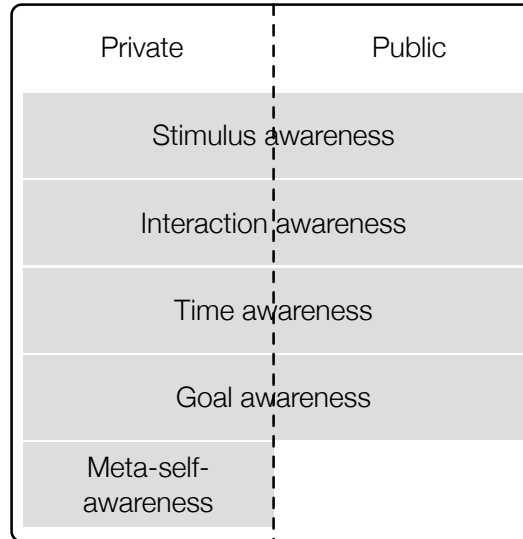


Fig. 2.1 Levels of computational self-awareness, and how they relate to private and public aspects in this framework. While the first four levels can involve perception and conceptualisation of either internal (private) or external (public) factors, meta-self-awareness is concerned with awareness of other self-aware processes, which are private to the individual.

basis throughout the system’s lifetime that enables self-awareness. We do not consider a system with knowledge but no means to update or add to that knowledge during its lifetime to be computationally self-aware: it has instead been programmed by a domain expert. While the levels are considered from an architectural perspective in Chapters 4 and 5, Chapters 6 and 7 consider how online learning and knowledge representation techniques can realise these characteristics of self-aware systems on an ongoing basis.

2.3.3 *Collective and Emergent Computational Self-aware Systems*

Finally, self-awareness can be, and indeed is often, found in complex systems composed of many interacting subsystems. This is important for the design of self-aware computing systems. In building self-aware systems, we do not need to require a global “knowledge base” or common awareness mediator. Indeed, in many natural systems, such components are absent [272]. Whether a self-aware system is organised in a centralised or a decentralised manner is, we argue, not a conceptual difference, but an architectural one. We anticipate that, and indeed several of the examples given in this book show that, decentralised self-awareness can provide increased robustness and adaptability in the face of change.

The third key concept inspiring our framework is therefore the notion that self-awareness can be a property of a collective system, possibly even emerging from interactions within the collective. Systems within a collective that interact with each other only locally as part of a bigger system might not individually possess knowledge about the system as a whole (i.e., the global state). Global knowledge is instead distributed [272], but the system is able to collectively use this information such that it has a sense of its own state and thus be self-aware at one or more of the aforementioned levels. Figure 2.2 illustrates that, from the conceptual point of view, a collective system comprising several self-aware systems may itself be viewed as a self-aware system, and considered using the computational self-awareness framework introduced in this book.

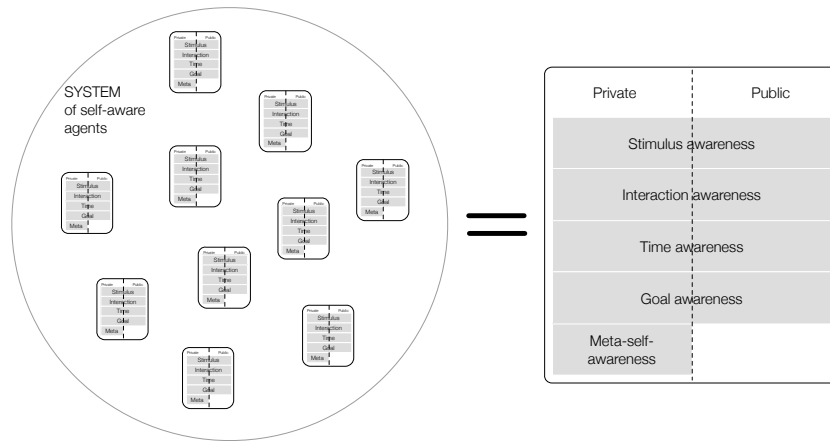


Fig. 2.2 Aspects of computational self-awareness can be considered when taking a single system view, and at subsystem level when composing a collective system. The relationship between these two may be complex, and exhibit emergent self-awareness properties.

When we talk of self-aware computing systems, we may therefore be referring to several different types of self. First, it should by now be clear that self-awareness may be a property of an autonomous agent, which is capable of obtaining and representing knowledge concerning itself and its experiences. Indeed, much of the literature on autonomous and intelligent agents is concerned with techniques for agent learning, knowledge acquisition and representation, and architectures to support these capabilities. Second, according to this third key idea of collective self-awareness, the boundary of a self-aware entity, indeed the “self”, is not limited to a single agent. Chapter 4 revisits this idea, in the context of architecture, and considers both centralised and decentralised approaches.

2.4 Summary

This chapter presented a brief introduction to self-awareness concepts as they are understood in humans. Further, we have begun to consider how such concepts can be translated to the domain of computing systems. The new notion of *computational self-awareness* is proposed, based on three key concepts:

- **Public and private self-awareness:** A self-aware system can have the ability to obtain knowledge based on phenomena that are external and internal to itself, respectively.
- **Levels of self-awareness:** The self-awareness of a system can be described in terms of one or more levels of self-awareness, which characterise self-awareness capabilities. We presented a set of levels inspired by psychology, comprising stimulus-awareness, interaction-awareness, time-awareness, goal-awareness and meta-self-awareness.
- **Collective self-awareness:** Self-awareness may be present at the level of a single system, or at the level of a collective system, where interactions between components provide distributed learning.

Additionally, we introduced the notion of *self-expression*, behaviour based on self-awareness. Self-expression typically provides highly dynamic behaviour, able to adapt to a system's changing self-awareness as it learns. Self-expression may include behaviours considered "normal" functional system behaviour, as well as self-adaptation, self-reconfiguration, self-explanation, or any other forms of individual or collective behaviour informed by a system's self-awareness.

These concepts are used as the basis for much of the work in subsequent chapters in this book, where architectures, algorithms, platforms and case studies expand on and demonstrate their use.

Acknowledgements

The research leading to these results was conducted in the EPiCS project (Engineering Proprioception in Computing Systems) and received funding from the European Union Seventh Framework Programme under grant agreement no. 257906.

The contributors would like to acknowledge additional financial support for research performed in individual chapters of this book.

- Chapters 6 and 7 were also supported by EPSRC Grants (Nos. EP/I010297/1, EP/K001523/1 and EP/J017515/1).
- Chapter 8 was also supported by the German Research Foundation (DFG) within the Collaborative Research Centre “On-The-Fly Computing” (SFB 901) and the International Graduate School on Dynamic Intelligent Systems of Paderborn University.
- Chapter 9 was also supported in part by HiPEAC NoE, by the European Union Seventh Framework Programme under grant agreement numbers 287804 and 318521, by the UK EPSRC, by the Maxeler University Programme, and by Xilinx.
- Chapter 12 was also supported in part by the China Scholarship Council, by the European Union Seventh Framework Programme under grant agreement numbers 287804 and 318521, by the UK EPSRC, by the Maxeler University Programme, and by Xilinx.
- Chapter 13 was also supported by the research initiative Mobile Vision with funding from the Austrian Institute of Technology and the Austrian Federal Ministry of Science, Research and Economy HRSMV programme BGBI. II no. 292/2012.
- Chapter 14 was also supported by the Research Council of Norway under grant agreement number 240862/F20.
- Peter Lewis would like to thank the participants of the Dagstuhl Seminar “Model-Driven Algorithms and Architectures for Self-aware Computing Systems”, Seminar Number 15041, for many insightful discussions on notions of self-aware computing.

References

1. Aberdeen, D., Baxter, J.: Emerald: a fast matrix-matrix multiply using Intel’s SSE instructions. *Concurrency and Computation: Practice and Experience* **13**(2), 103–119 (2001)
2. Abramowitz, M., Stegun, I.: *Handbook of Mathematical Functions*. Dover Publications (1965)
3. Agarwal, A., Harrod, B.: Organic computing. Tech. Rep. White paper, MIT and DARPA (2006)
4. Agarwal, A., Miller, J., Eastep, J., Wentziaff, D., Kasture, H.: Self-aware computing. Tech. Rep. AFRL-RI-RS-TR-2009-161, MIT (2009)

5. Agne, A., Hangmann, H., Happe, M., Platzner, M., Plessl, C.: Seven recipes for setting your FPGA on fire – a cookbook on heat generators. *Microprocessors and Microsystems* **38**(8), 911–919 (2014). DOI 10.1016/j.micpro.2013.12.001
6. Agne, A., Happe, M., Keller, A., Lübbers, E., Plattner, B., Platzner, M., Plessl, C.: ReconOS: An Operating System Approach for Reconfigurable Computing. *IEEE Micro* **34**(1), 60–71 (2014). DOI 10.1109/MM.2013.110
7. Agne, A., Platzner, M., Lübbers, E.: Memory virtualization for multithreaded reconfigurable hardware. In: *Proceedings of the International Conference on Field Programmable Logic and Applications (FPL)*, pp. 185–188. IEEE Computer Society (2011). DOI 10.1109/FPL.2011.42
8. Ahuja, S., Carriero, N., Gelernter, D.: Linda and friends. *IEEE Computer* **19**(8), 26–34 (1986). DOI 10.1109/MC.1986.1663305
9. Al-Naeem, T., Gorton, I., Babar, M.A., Rabhi, F., Benatallah, B.: A quality-driven systematic approach for architecting distributed software applications. In: *Proceedings of the 27th International Conference on Software Engineering*, pp. 244–253. ACM (2005). DOI 10.1145/1062455.1062508. URL <http://doi.acm.org/10.1145/1062455.1062508>
10. Ali, H.A., Desouky, A.I.E., Saleh, A.I.: Studying and Analysis of a Vertical Web Page Classifier Based on Continuous Learning Naive Bayes (CLNB) Algorithm, pp. 210–254. *Information Science* (2009)
11. Alippi, C., Boracchi, G., Roveri, M.: Just-in-time classifiers for recurrent concepts. *IEEE Transactions on Neural Networks and Learning Systems* **24**(4), 620–634 (2013)
12. Amir, E., Anderson, M.L., Chaudhri, V.K.: Report on DARPA workshop on self-aware computer systems. Tech. Rep. UIUCDCS-R-2007-2810, UIUC Comp. Sci. (2007)
13. ANA: Autonomic Network Architecture. URL www.ana-project.org. (accessed March 8, 2016)
14. Angelov, P.: Nature-inspired methods for knowledge generation from data in real-time (2006). URL http://www.nisis.risk-technologies.com/popup/Mallorca2006_Papers/A333_13774_Nature-inspiredmethodsforKnowledgeGeneration_Angelov.pdf
15. Apache: Hadoop. http://hadoop.apache.org/docs/r1.2.1/mapred_tutorial.html. (Accessed March 8, 2016)
16. Araya-Polo, M., Cabezas, J., Hanzich, M., Pericàs, M., Rubio, F., Gelado, I., Shafiq, M., Morancho, E., Navarro, N., Ayguadé, E., Cela, J.M., Valero, M.: Assessing accelerator-based HPC reverse time migration. *IEEE Transactions on Parallel and Distributed Systems* **22**(1), 147–162 (2011)
17. Asanovic, K., Bodik, R., Catanzaro, B.C., Gebis, J.J., Husbands, P., Keutzer, K., Patterson, D.A., Plishker, W.L., Shalf, J., Williams, S.W., Yelick, K.A.: The landscape of parallel computing research: A view from Berkeley. Tech. Rep. UCB/EECS-2006-183, EECS Department, University of California, Berkeley (2006)
18. Asendorpf, J.B., Warkentin, V., Baudonnière, P.M.: Self-awareness and other-awareness. II: Mirror self-recognition, social contingency awareness, and synchronic imitation. *Developmental Psychology* **32**(2), 313 (1996)
19. Athan, T.W., Papalambros, P.Y.: A note on weighted criteria methods for compromise solutions in multi-objective optimization. *Engineering Optimization* **27**(2), 155–176 (1996)
20. Auer, P., Cesa-Bianchi, N., Fischer, P.: Finite-time analysis of the multiarmed bandit problem. *Machine Learning* **47**(2–3), 235–256 (2002)
21. Babaoglu, O., Binci, T., Jelasity, M., Montresor, A.: Firefly-inspired heartbeat synchronization in overlay networks. In: *First International Conference on Self-Adaptive and Self-Organizing Systems (SASO)*, pp. 77–86 (2007)
22. Babenko, B., Yang, M.H., Belongie, S.: Robust object tracking with online multiple instance learning. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **33**(8), 1619–1632 (2011)
23. Bader, J., Zitzler, E.: HypE: an algorithm for fast hypervolume-based many-objective optimization. Tech. Rep. TIK 286, Computer Engineering and Networks Laboratory, ETH Zurich, Zurich (2008)

24. Baena-García, M., Campo-Ávila, J.D., Fidalgo, R., Bifet, A.: Early drift detection method. In: Proceedings of the 4th ECML PKDD International Workshop on Knowledge Discovery From Data Streams (IWKDDs), pp. 77–86. Berlin, Germany (2006)
25. Baker, S.: The identification of the self. *Psyc. Rev.* **4**(3), 272–284 (1897)
26. Banks, A., Gupta, R.: MQTT Version 3.1.1. <http://docs.oasis-open.org/mqtt/mqtt/v3.1.1/os/mqtt-v3.1.1-os.html> (2014)
27. Bartolini, D.B., Sironi, F., Maggio, M., Cattaneo, R., Sciuto, D., Santambrogio, M.D.: A Framework for Thermal and Performance Management. In: Proceedings of the Workshop on Managing Systems Automatically and Dynamically (MAD) (2012)
28. Basheer, I.A., Hajmeer, M.: Artificial neural networks: fundamentals, computing, design, and application. *Journal of Microbiological Methods* **43**(1), 3–31 (2000)
29. Basseur, M., Zitzler, E.: Handling uncertainty in indicator-based multiobjective optimization. *International Journal of Computational Intelligence Research* **2**(3), 255–272 (2006)
30. Basudhar, A., Dribusch, C., Lacaze, S., Missoum, S.: Constrained efficient global optimization with support vector machines. *Structural and Multidisciplinary Optimization* **46**(2), 201–221 (2012)
31. Baumann, A., Boltz, M., Ebling, J., Koenig, M., Loos, H.S., Merkel, M., Niem, W., Warzelhan, J.K., Yu, J.: A review and comparison of measures for automatic video surveillance systems. *EURASIP Journal on Image and Video Processing* **2008**(4) (2008). DOI 10.1155/2008/824726
32. Becker, T., Agne, A., Lewis, P.R., Bahsoon, R., Faniyi, F., Esterle, L., Keller, A., Chandra, A., Jensenius, A.R., Stilkerich, S.C.: EPiCS: Engineering proprioception in computing systems. In: Proceedings of the International Conference on Computational Science and Engineering (CSE), pp. 353–360. IEEE Computer Society (2012)
33. Ben-Hur, A., Weston, J.: A user’s guide to support vector machines. *Data Mining Techniques for the Life Sciences* **609**, 223–239 (2010)
34. Betts, A., Chong, N., Donaldson, A.F., Qadeer, S., Thompson, P.: GPUVerify: a verifier for GPU kernels. In: Proceedings of the ACM International Conference on Object-Oriented Programming Systems Languages and Applications (OOPSLA) (2012)
35. Beume, N., Naujoks, B., Emmerich, M.: SMS-EMOA: Multiobjective selection based on dominated hypervolume. *European Journal on Operational Research* **181**(3), 1653–1669 (2007)
36. Bevilacqua, F., Zamborlin, B., Sypniewski, A., Schnell, N., Guédy, F., Rasamimanana, N.: Continuous realtime gesture following and recognition. In: *Gesture in embodied communication and human-computer interaction*, pp. 73–84. Springer (2010)
37. Biehl, J.T., Adamczyk, P.D., Bailey, B.P.: Djogger: A mobile dynamic music device. In: Proceedings of CHI ’06 Extended Abstracts on Human Factors in Computing Systems, pp. 556–561. ACM (2006)
38. Bishop, C.M.: *Neural Networks for Pattern Recognition*. Oxford University Press, United Kingdom (2005)
39. Bojic, I., Lipic, T., Podobnik, V.: Bio-inspired clustering and data diffusion in machine social networks. In: *Computational Social Networks*, pp. 51–79. Springer (2012)
40. Bongard, J., Lipson, H.: Evolved machines shed light on robustness and resilience. *Proceedings of the IEEE* **102**(5), 899–914 (2014)
41. Bongard, J., Zykov, V., Lipson, H.: Resilient machines through continuous self-modeling. *Science* **314**(5802), 1118–1121 (2006)
42. Borkar, S.: Designing Reliable Systems from Unreliable Components: The Challenges of Transistor Variability and Degradation. *IEEE Micro* pp. 10–16 (2005)
43. Bouabene, G., Jelger, C., Tschudin, C., Schmid, S., Keller, A., May, M.: The Autonomic Network Architecture (ANA). *IEEE Journal on Selected Areas in Communications* **28**(1), 4–14 (2010). DOI 10.1109/JSAC.2010.100102
44. Boyd, J.: *The Essence of Winning and Losing*. <http://dnipogo.org/john-r-boyd/> (1996). (Accessed March 8, 2016)
45. Bramberger, M., Doblender, A., Maier, A., Rinner, B., Schwabach, H.: Distributed Embedded Smart Cameras for Surveillance Applications. *IEEE Computer* **39**(2), 68–75 (2006)

46. Brdiczka, O., Crowley, J.L., Reignier, P.: Learning situation models in a smart home. *IEEE Transactions on Systems, Man, and Cybernetics, Part B* **39**, 56–63 (2009)
47. Breiman, L.: Bagging predictors. *Machine Learning* **24**(2), 123–140 (1996)
48. Breiman, L.: Random forests. *Machine Learning* **45**(1), 5–32 (2001)
49. Brockhoff, D., Zitzler, E.: Improving hypervolume-based multiobjective evolutionary algorithms by using objective reduction methods. In: *Proceedings of the 2007 IEEE Congress on Evolutionary Computation*, pp. 2086–2093 (2007)
50. Buchanan, J.T.: A naive approach for solving MCDM problems: The GUESS method. *Journal of the Operational Research Society* **48**(2), 202–206 (1997)
51. Buck, J.: Synchronous rhythmic flashing of fireflies. *The Quarterly Review of Biology* **13**(3), 301–314 (1938)
52. Buck, J.: Synchronous rhythmic flashing of fireflies II. *The Quarterly Review of Biology* **63**(3), 265–289 (1988)
53. Burke, E.K., Gendreau, M., Hyde, M., Kendall, G., Ochoa, G., Ozcan, E., Qu, R.: Hyperheuristics: A survey of the state of the art. *Journal of the Operational Research Society* **206**(1), 241–264 (2013)
54. Buschmann, F., Henney, K., Douglas, S.C.: *Pattern-oriented software architecture: On patterns and pattern languages*. John Wiley and Sons (2007)
55. Buss, A.H.: *Self-consciousness and social anxiety*. W. H. Freeman, San Fransisco, CA, USA (1980)
56. Calinescu, R., Ghezzi, C., Kwiatkowska, M., Mirandola, R.: Self-adaptive software needs quantitative verification at runtime. *Communications of the ACM* **55**(9), 69–77 (2012)
57. Caramiaux, B., Wanderley, M.M., Bevilacqua, F.: Segmenting and parsing instrumentalists' gestures. *Journal of New Music Research* **41**(1), 13–29 (2012)
58. Carver, C.S., Scheier, M.: *Attention and Self-Regulation: A Control-Theory Approach to Human Behavior*. Springer (1981)
59. de Castro, L.N.: *Fundamentals of natural computing: basic concepts, algorithms, and applications*. Chapman & Hall/CRC Computer and Information Sciences (2006)
60. Chandra, A.: A methodical framework for engineering co-evolution for simulating socio-economic game playing agents. Ph.D. thesis, The University of Birmingham (2011)
61. Chandra, A., Nymoen, K., Volsund, A., Jensenius, A.R., Glette, K., Torresen, J.: Enabling participants to play rhythmic solos within a group via auctions. In: *Proceedings of the International Symposium on Computer Music Modeling and Retrieval (CMMR)*, pp. 674–689 (2012)
62. Chandra, A., Yao, X.: Ensemble learning using multi-objective evolutionary algorithms. *Journal of Mathematical Modelling and Algorithms* **5**(4), 417–445 (2006)
63. Chang, C., Wawrzynek, J., Brodersen, R.W.: BEE2: a high-end reconfigurable computing system. *IEEE Transactions on Design & Test of Computer* **22**(2), 114–125 (2005)
64. Chen, J., John, L.K.: Efficient program scheduling for heterogeneous multi-core processors. In: *Proceedings of the Design Automation Conference (DAC)*. ACM (2009)
65. Chen, R., Lewis, P.R., Yao, X.: Temperature management for heterogeneous multi-core FPGAs using adaptive evolutionary multi-objective approaches. In: *Proceedings of the International Conference on Evolvable Systems (ICES)*, pp. 101–108. IEEE (2014)
66. Chen, S., Langner, C.A., Mendoza-Denton, R.: When dispositional and role power fit: implications for self-expression and self-other congruence. *Journal of Personality and Social Psychology* **96**(3), 710–727 (2009)
67. Chen, T., Bahsoon, R.: Self-adaptive and Sensitivity-aware QoS Modeling for the Cloud. In: *Proceedings of the 8th International Symposium on Software Engineering for Adaptive and Self-Managing Systems (SEAMS)*, pp. 43–52. IEEE (2013). URL <http://dl.acm.org/citation.cfm?id=2487336.2487346>
68. Chen, T., Bahsoon, R.: Symbiotic and Sensitivity-aware Architecture for Globally-optimal Benefit in Self-adaptive Cloud. In: *Proceedings of the 9th International Symposium on Software Engineering for Adaptive and Self-Managing Systems (SEAMS)*, pp. 85–94. ACM (2014). DOI 10.1145/2593929.2593931. URL <http://doi.acm.org/10.1145/2593929.2593931>

69. Chen, T., Bahsoon, R., Yao, X.: Online QoS Modeling in the Cloud: A Hybrid and Adaptive Multi-learners Approach. In: 2014 IEEE/ACM 7th International Conference on Utility and Cloud Computing (UCC), pp. 327–336 (2014)
70. Chen, T., Faniyi, F., Bahsoon, R., Lewis, P.R., Yao, X., Minku, L.L., Esterle, L.: The handbook of engineering self-aware and self-expressive systems. Tech. rep., EPiCS EU FP7 project consortium (2014). URL <http://arxiv.org/abs/1409.1793>. Available via EPiCS website and arXiv
71. Chen, X., Li, X., Wu, H., Qiu, T.: Real-time Object Tracking via CamShift-based Robust Framework. In: Proceedings of the International Conference on Information Science and Technology (ICIST). IEEE (2012)
72. Chow, G.C.T., Grigoras, P., Burovskiy, P., Luk, W.: An efficient sparse conjugate gradient solver using a Beneš permutation network. In: Proceedings of the 24th International Conference on Field Programmable Logic and Applications, pp. 1–7 (2014)
73. Chow, G.C.T., Tse, A.H.T., Jin, Q., Luk, W., Leong, P.H.W., Thomas, D.B.: A mixed precision Monte Carlo methodology for reconfigurable accelerator systems. In: Proceedings of the ACM/SIGDA 20th International Symposium on Field Programmable Gate Arrays, FPGA 2012, Monterey, California, USA, February 22–24, 2012, pp. 57–66 (2012)
74. Christensen, A.L., O’Grady, R., Dorigo, M.: From fireflies to fault-tolerant swarms of robots. *IEEE Transactions on Evolutionary Computation* **13**(4), 754–766 (2009)
75. Christensen, E., Curbera, F., Meredith, G., Weerawarana, S.: Web Services Description Language (WSDL) 1.1. World Wide Web Consortium (2001)
76. Chu, F., Zaniolo, C.: Fast and light boosting for adaptive mining of data streams. In: Proceedings of the Eighth Pacific-Asia Knowledge Discovery and Data Mining Conference (PAKDD), pp. 282–292. Sydney (2004)
77. Cichowski, A., Madden, C., Detmold, H., Dick, A., Van den Hengel, A., Hill, R.: Tracking Hand-off in Large Surveillance Networks. In: Proceedings of the International Conference Image and Vision Computing, pp. 276–281. IEEE Computer Society Press (2009). DOI 10.1109/IVCNZ.2009.5378396
78. Claus, C., Boutilier, C.: The Dynamics of Reinforcement Learning in Cooperative Multiagent Systems. In: Proceedings of the Conference on Artificial Intelligence/Innovative Applications of Artificial Intelligence, pp. 746–752. American Association for Artificial Intelligence (1998)
79. Collins, N.: The analysis of generative music programs. *Organised Sound* **13**, 237–248 (2008)
80. Collins, R.T., Liu, Y., Leordeanu, M.: Online selection of discriminative tracking features. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **27**(10), 1631–1643 (2005). DOI 10.1109/tpami.2005.205
81. Colomi, A., Dorigo, M., Maniezzo, V., et al.: Distributed optimization by ant colonies. In: Proceedings of the first European conference on artificial life, vol. 142, pp. 134–142. Elsevier (1991)
82. Comaniciu, D., Ramesh, V., Meer, P.: Kernel-based object tracking. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **25**(5) (2003). DOI 10.1109/tpami.2003.1195991
83. Connors, K.: Chemical kinetics: the study of reaction rates in solution. VCH Publishers (1990)
84. Cox, M.: Metacognition in computation: A selected research review. *Artificial Intelligence* **169**(2), 104–141 (2005)
85. Cramer, T., Schmidl, D., Klemm, M., an Mey, D.: OpenMP Programming on Intel Xeon Phi Coprocessors: An Early Performance Comparison. In: Proceedings of the Many-core Applications Research Community (MARC) Symposium, pp. 38–44. Aachen, Germany (2012)
86. Crockford, D.: The application/json Media Type for JavaScript Object Notation (JSON). RFC 7159, RFC Editor (2014). URL <http://tools.ietf.org/pdf/rfc7159.pdf>
87. Curreri, J., Stitt, G., George, A.D.: High-level synthesis of in-circuit assertions for verification, debugging, and timing analysis. *International Journal of Reconfigurable Computing* **2011**, 1–17 (2011). DOI <http://dx.doi.org/10.1155/2011/406857>

88. Czajkowski, T.S., Aydonat, U., Denisenko, D., Freeman, J., Kinsner, M., Neto, D., Wong, J., Yiannacouras, P., Singh, D.P.: From OpenCL to high-performance hardware on FPGAs. In: Proceedings of the 22nd International Conference on Field Programmable Logic and Applications (FPL), pp. 531–534. Oslo, Norway (2012)
89. Datta, K., Murphy, M., Volkov, V., Williams, S., Carter, J., Oliner, L., Patterson, D., Shalf, J., Yelick, K.: Stencil computation optimization and auto-tuning on state-of-the-art multi-core architectures. In: Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis (SC 2008), p. 4. IEEE (2008)
90. Davidson, A.A., Owens, J.D.: Toward techniques for auto-tuning GPU algorithms. In: Proceedings of the 10th International Conference on Applied Parallel and Scientific Computing (PARA), Revised Selected Papers, Part II, pp. 110–119. Reykjavík (2010)
91. Day, J.: Patterns in Network Architecture: A Return to Fundamentals. Prentice Hall International (2008)
92. Day, J., Matta, I., Mattar, K.: Networking is IPC: A Guiding Principle to a Better Internet. In: Proceedings of the 2008 ACM CoNEXT Conference, pp. 67:1–67:6 (2008). DOI 10.1145/1544012.1544079. URL <http://doi.acm.org/10.1145/1544012.1544079>
93. Dean, J., Ghemawat, S.: MapReduce: Simplified Data Processing on Large Clusters. In: Proceedings of the 6th Symposium on Operating System Design and Implementation (OSDI), pp. 137–150. San Francisco, California, USA (2004)
94. Deb, K.: Multi-objective optimization using evolutionary algorithms, vol. 16. John Wiley & Sons, England (2001)
95. Deb, K., Pratap, A., Agarwal, S., Meyarivan, T.: A fast and elitist multiobjective genetic algorithm: NSGA-II. *IEEE Transactions on Evolutionary Computation* **6**(2), 182–197 (2002)
96. Denholm, S., Inoue, H., Takenaka, T., Luk, W.: Application-specific customisation of market data feed arbitration. In: Proceedings of the International Conference on Field Programmable Technology (ICFPT), pp. 322–325. IEEE (2013)
97. Denholm, S., Inouey, H., Takenakay, T., Becker, T., Luk, W.: Low latency FPGA acceleration of market data feed arbitration. In: Proceedings of the International Conference on Application-Specific Systems, Architectures, and Processors (ASAP), pp. 36–40. IEEE (2014). DOI 10.1109/ASAP.2014.6868628
98. Dennett, D.C.: *Consciousness Explained*. Penguin Science (1993)
99. Dennis, J.B., Misunas, D.: A preliminary architecture for a basic data flow processor. In: Proceedings of the 2nd Annual Symposium on Computer Architecture, pp. 126–132 (1974)
100. Dieber, B., Simonjan, J., Esterle, L., Rinner, B., Nebehay, G., Pflugfelder, R., Fernandez, G.J.: Ella: Middleware for multi-camera surveillance in heterogeneous visual sensor networks. In: Proceedings of the International Conference on Distributed Smart Cameras (ICDSC) (2013). DOI 10.1109/ICDSC.2013.6778223
101. Dietterich, T.G.: Ensemble methods in machine learning. In: Proceedings of the First International Workshop on Multiple Classifier Systems, Lecture Notes in Computer Science, pp. 1–15. Springer-Verlag (2000)
102. Diguët, J.P., Eustache, Y., Gogniat, G.: Closed-loop-based Self-adaptive Hardware/Software-Embedded Systems: Design Methodology and Smart Cam Case Study. *ACM Transactions on Embedded Computing Systems* **10**(3), 1–28 (2011)
103. Dinh, M.N., Abramson, D., J. Chao, D.K., Gontarek, A., Moench, B., DeRose, L.: Debugging scientific applications with statistical assertions. *Procedia Computer Science* **9**(0), 1940–1949 (2012)
104. Dobson, S., Denazis, S., Fernández, A., Gaïti, D., Gelenbe, E., Massacci, F., Nixon, P., Saffre, F., Schmidt, N., Zambonelli, F.: A survey of autonomic communications. *ACM Transactions on Autonomous and Adaptive Systems* **1**(2), 223–259 (2006)
105. Dobson, S., Sterritt, R., Nixon, P., Hinchey, M.: Fulfilling the vision of autonomic computing. *IEEE Computer* **43**(1), 35–41 (2010)
106. Dobzhansky, T., Hecht, M., Steere, W.: On some fundamental concepts of evolutionary biology. *Evolutionary Biology* **2**, 1–34 (1968)
107. Dorigo, M.: Optimization, learning and natural algorithms. Ph.D. thesis, Politecnico di Milano (1992)

108. Dorigo, M., Blum, C.: Ant colony optimization theory: A survey. *Theoretical computer science* **344**(2), 243–278 (2005)
109. Dorigo, M., Maniezzo, V., Colomi, A.: Ant system: optimization by a colony of cooperating agents. *IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics* **26**(1), 29–41 (1996)
110. Dutta, R., Rouskas, G., Baldine, I., Bragg, A., Stevenson, D.: The SILO Architecture for Services Integration, controL, and Optimization for the Future Internet. In: *Proceedings of the IEEE International Conference on Communications (ICC)*, pp. 1899–1904 (2007). DOI 10.1109/ICC.2007.316
111. Duval, S., Wicklund, R.A.: *A theory of objective self awareness*. Academic Press (1972)
112. Ehrgott, M.: Other Methods for Pareto Optimality. In: *Multicriteria Optimization, Lecture Notes in Economics and Mathematical Systems*, vol. 491, pp. 77–102. Springer (2000)
113. Eiben, A.E., Smith, J.E.: *Introduction to evolutionary computing*. Springer (2003)
114. Eigenfeldt, A., Pasquier, P.: Considering vertical and horizontal context in corpus-based generative electronic dance music. In: *Proceedings of the Fourth International Conference on Computational Creativity*, p. 72 (2013)
115. Eigenfeldt, A., Pasquier, P.: Evolving structures for electronic dance music. In: *Proceedings of the 15th Annual Conference on Genetic and Evolutionary Computation (GECCO)*, pp. 319–326. ACM (2013)
116. Elkhodary, A., Esfahani, N., Malek, S.: FUSION: a framework for engineering self-tuning self-adaptive software systems. In: *Proceedings of the eighteenth ACM SIGSOFT International Symposium on Foundations of Software Engineering*, pp. 7–16. ACM (2010). DOI 10.1145/1882291.1882296. URL <http://doi.acm.org/10.1145/1882291.1882296>
117. Elliott, G.T., Tomlinson, B.: PersonalSoundtrack: context-aware playlists that adapt to user pace. In: *Proceedings of CHI'06 Extended Abstracts on Human Factors in Computing Systems*, pp. 736–741. ACM (2006)
118. Ellis, T., Makris, D., Black, J.: Learning a Multi-camera Topology. In: *Proceedings of the Joint International Workshop on Visual Surveillance and Performance Evaluation of Tracking and Surveillance*, pp. 165–171. IEEE Computer Society Press (2003)
119. Elwell, R., Polikar, R.: Incremental learning of concept drift in nonstationary environments. *IEEE Transactions on Neural Networks* **22**, 1517–1531 (2011)
120. Endo, T., Matsuoka, S.: Massive supercomputing coping with heterogeneity of modern accelerators. In: *Proceedings of the 22nd IEEE International Symposium on Parallel and Distributed Processing (IPDPS)*, pp. 1–10 (2008)
121. Erdem, U.M., Sclaroff, S.: Look there! Predicting Where to Look for Motion in an Active Camera Network. In: *Proceedings of the IEEE Conference on Advanced Video and Signal-based Surveillance*, pp. 105–110. Como, Italy (2005)
122. Esterle, L., Lewis, P.R., Bogdanski, M., Rinner, B., Yao, X.: A socio-economic approach to online vision graph generation and handover in distributed smart camera networks. In: *Proceedings of the International Conference on Distributed Smart Cameras (ICDSC)*, pp. 1–6. IEEE (2011). DOI 10.1109/ICDSC.2011.6042902
123. Esterle, L., Lewis, P.R., Caine, H., Yao, X., Rinner, B.: CamSim: A distributed smart camera network simulator. In: *Proceedings of the International Conference on Self-Adaptive and Self-Organizing Systems Workshops*, pp. 19–20. IEEE Computer Society Press (2013). DOI 10.1109/SASOW.2013.11
124. Esterle, L., Lewis, P.R., Rinner, B., Yao, X.: Improved adaptivity and robustness in decentralised multi-camera networks. In: *Proceedings of the International Conference on Distributed Smart Cameras*, pp. 1–6. ACM (2012)
125. Esterle, L., Lewis, P.R., Yao, X., Rinner, B.: Socio-economic vision graph generation and handover in distributed smart camera networks. *ACM Transactions on Sensor Networks* **10**(2), 20:1–20:24 (2014). DOI 10.1145/2530001
126. Eugster, P.T., Felber, P.A., Guerraoui, R., Kermarrec, A.M.: The Many Faces of Publish/Subscribe. *ACM Computing Surveys* **35**(2), 114–131 (2003)

127. Faniyi, F., Lewis, P.R., Bahsoon, R., Xiao, X.: Architecting self-aware software systems. In: Proceedings of the IEEE/IFIP Conference on Software Architecture (WICSA), pp. 91–94. IEEE (2014)
128. Farrell, R., Davis, L.S.: Decentralized discovery of camera network topology. In: Proceedings of the International Conference on Distributed Smart Cameras, pp. 1–10. IEEE Computer Society Press (2008). DOI 10.1109/ICDSC.2008.4635696
129. Fels, S., Hinton, G.: Glove-talk: A neural network interface between a data-glove and a speech synthesizer. *IEEE Transactiona on Neural Networks* **4**(1), 2–8 (1993)
130. Feng, W.: Making a case for efficient supercomputing. *ACM Queue* **1**(7), 54–64 (2003)
131. Fenigstein, A., Scheier, M.F., Buss, A.H.: Public and private self-consciousness: Assessment and theory. *Journal of Consulting and Clinical Psychology* **43**(4), 522–527 (1975)
132. Fern, A., Givan, R.: Online ensemble learning: An empirical study. *Machine Learning* **53**(1–2), 71–109 (2003)
133. Fette, B.: *Cognitive radio technology*. Academic Press (2009)
134. Fiebrink, R., Trueman, D., Cook, P.R.: A meta-instrument for interactive, on-the-fly machine learning. In: Proceedings of the International Conference on New Interfaces for Musical Expression. Pittsburgh (2009)
135. Fielding, R.T., Taylor, R.N.: Principled design of the modern web architecture. *ACM Transactions on Internet Technology* **2**(2), 115–150 (2002). DOI 10.1145/514183.514185. URL <http://doi.acm.org/10.1145/514183.514185>
136. Freund, Y., Schapire, R.E.: Experiments with a new boosting algorithm. In: Proceedings of the 13th International Conference on Machine Learning, pp. 148–156 (1996)
137. Froming, W.J., Walker, G.R., Lopyan, K.J.: Public and private self-awareness: When personal attitudes conflict with societal expectations. *Journal of Experimental Social Psychology* **18**(5), 476 – 487 (1982). DOI 10.1016/0022-1031(82)90067-1
138. Fu, H., Sendhoff, B., Tang, K., Yao, X.: Finding robust solutions to dynamic optimization problems. In: Proceedings of the 16th European conference on Applications of Evolutionary Computation (EvoApplications), pp. 616–625 (2013)
139. Funie, A., Salmon, M., Luk, W.: A hybrid genetic-programming swarm-optimisation approach for examining the nature and stability of high frequency trading strategies. In: Proceedings of the 13th International Conference on Machine Learning and Applications (ICMLA), pp. 29–34. Detroit, USA (2014). DOI 10.1109/ICMLA.2014.11. URL <http://dx.doi.org/10.1109/ICMLA.2014.11>
140. Gallup, G.G.: Chimpanzees: self-recognition. *Science* (1970)
141. Gama, J., Medas, P., Castillo, G., Rodrigues, P.: Learning with drift detection. In: Proceedings of the 7th Brazilian Symposium on Artificial Intelligence (SBIA) - Lecture Notes in Computer Science, vol. 3171, pp. 286–295. Springer, São Luiz do Maranhão, Brazil (2004)
142. Gao, J., Fan, W., Han, J.: On appropriate assumptions to mine data streams: Analysis and practice. In: Proceedings of the Seventh IEEE International Conference on Data Mining (ICDM), pp. 143–152 (2007)
143. Garlan, D., Cheng, S.W., Huang, A.C., Schmerl, B., Steenkiste, P.: Rainbow: architecture-based self-adaptation with reusable infrastructure. *IEEE Computer* **37**(10), 46–54 (2004)
144. Gelenbe, E., Loukas, G.: A self-aware approach to denial of service defence. *Computer Networks* **51**(5), 1299–1314 (2007)
145. Goto, M.: Active music listening interfaces based on signal processing. In: Proceedings of the IEEE International Conference on Acoustics, Speech and Signal Processing, vol. 4, pp. 1441–1444 (2007)
146. Gouin-Vallerand, C., Abdulrazak, B., Giroux, S., Mokhtari, M.: Toward autonomic pervasive computing. In: Proceedings of the 10th International Conference on Information Integration and Web-based Applications & Services, iiWAS '08, pp. 673–676. ACM, New York, NY, USA (2008)
147. Goukens, C., Dewitte, S., Warlop, L.: Me, myself, and my choices: The influence of private self-awareness on preference-behavior consistency. Tech. rep., Katholieke Universiteit Leuven (2007)

148. Grabner, H., Bischof, H.: On-line Boosting and Vision. In: Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition, pp. 260–267 (2006)
149. Grabner, H., Leistner, C., Bischof, H.: Semi-supervised on-line Boosting for Robust Tracking. In: Proceedings of the European Conference on Computer Vision, Lecture Notes in Computer Science, vol. 5302, pp. 234–247 (2008)
150. Group, K.: The OpenCL specification, version: 1.1. <http://www.khronos.org/registry/cl/specs/opencl-1.1.pdf>. (Accessed March 8, 2016)
151. Gudger, E.W.: A historical note on the synchronous flashing of fireflies. *Science* **50**(1286), 188–190 (1919)
152. Gudgin, M., Hadley, M., Mendelsohn, N., Moreau, J.J., Nielsen, H.F., Karmarkar, A., Lafon, Y.: SOAP Version 1.2. World Wide Web Consortium (2007)
153. Guo, C., Luk, W.: Accelerating Maximum Likelihood Estimation for Hawkes Point Processes. In: Proceedings of the International Conference on Field Programmable Logic and Applications (FPL), pp. 1–6. IEEE (2013)
154. Guo, C., Luk, W.: Accelerating parameter estimation for multivariate self-exciting point processes. In: Proceedings of the International Symposium on Field-Programmable Gate Arrays (FPGA), pp. 181–184. ACM (2014). DOI 10.1145/2554688.2554765
155. Haikonen, P.O.: Reflections of consciousness: The mirror test. In: Proceedings of the AAAI Fall Symposium on Consciousness and Artificial Intelligence, pp. 67–71 (2007)
156. Hamid, R., Maddi, S., Johnson, A., Bobick, A., Essa, I., Isbell, C.: A novel sequence representation for unsupervised analysis of human activities. *Artificial Intelligence* **173**(14), 1221–1244 (2009). DOI 10.1016/j.artint.2009.05.002
157. Hansen, N.: The CMA evolution strategy: A comparing review. In: J. Lozano, P. Larrañaga, I. Inza, E. Bengoetxea (eds.) *Towards a New Evolutionary Computation, Studies in Fuzziness and Soft Computing*, vol. 192, pp. 75–102. Springer Berlin Heidelberg (2006)
158. Happe, M., Agne, A., Plessl, C.: Measuring and Predicting Temperature Distributions on FPGAs at Run-Time. In: Proceedings of the International Conference on Reconfigurable Computing and FPGAs (ReConFig), pp. 55–60. IEEE Computer Society (2011). DOI 10.1109/ReConFig.2011.59
159. Happe, M., Huang, Y., Keller, A.: Dynamic Protocol Stacks in Smart Camera Networks. In: Proceedings of the International Conference on Reconfigurable Computing and FPGAs (ReConFig), pp. 1–6. IEEE (2014)
160. Happe, M., Traber, A., Keller, A.: Preemptive Hardware Multitasking in ReconOS. In: Proceedings of the International Symposium on Applied Reconfigurable Computing (ARC), Springer (2015)
161. Hart, J.W., Scassellati, B.: Robotic self-modeling. In: J. Pitt (ed.) *The Computer After Me*, pp. 207–218. Imperial College Press / World Scientific Book (2014)
162. Heath, D., Jarrow, R., Morton, A.: Bond pricing and the term structure of interest rates: A new methodology for contingent claims valuation. *Econometrica* **60**(1), 77–105 (1992)
163. Hernandez, H., Blum, C.: Distributed graph coloring in wireless ad hoc networks: A light-weight algorithm based on Japanese tree frogs’ calling behaviour. In: Proceedings of the 4th Joint IFIP Wireless and Mobile Networking Conference (WMNC), pp. 1–7 (2011)
164. Herzen, B.V.: Signal Processing at 250 MHz Using High-Performance FPGAs. In: Proceedings of the ACM Fifth International Symposium on Field-programmable Gate Arrays, pp. 62–68 (1997)
165. Ho, T.K.: The Random Subspace Method for Constructing Decision Forests. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **20**(8), 832–844 (1998)
166. Ho, T.K., Hull, J.J., Srikari, S.N.: Decision Combination in Multiple Classifier Systems. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **16**(1), 66–75 (1994)
167. Ho, T.S.Y., Lee, S.B.: Term Structure Movements and Pricing Interest Rate Contingent Claims. *Journal of Finance* **41**(5), 1011–1029 (1986)
168. Hoare, C.A.R.: An axiomatic basis for computer programming. *Communications of the ACM* **12**(10), 576–580 (1969)

169. Hockman, J.A., Wanderley, M.M., Fujinaga, I.: Real-time phase vocoder manipulation by runner's pace. In: Proceedings of the International Conference on New Interfaces for Musical Expression (2009)
170. Hoffmann, H., Eastep, J., Santambrogio, M., Miller, J., Agarwal, A.: Application heartbeats for software performance and health. In: ACM SIGPLAN Notices, vol. 45, pp. 347–348. ACM (2010)
171. Hoffmann, H., Eastep, J., Santambrogio, M.D., Miller, J.E., Agarwal, A.: Application Heartbeats: A Generic Interface for Specifying Program Performance and Goals in Autonomous Computing Environments. In: Proceedings of the International Conference on Autonomic Computing (ICAC) (2010)
172. Hoffmann, H., Holt, J., Kurian, G., Lau, E., Maggio, M., Miller, J.E., Neuman, S.M., Sinangil, M., Sinangil, Y., Agarwal, A., Chandrakasan, A.P., Devadas, S.: Self-aware computing in the Angstrom processor. In: Proceedings of the 49th Annual Design Automation Conference, DAC '12, pp. 259–264. ACM, New York, NY, USA (2012)
173. Hoffmann, H., Maggio, M., Santambrogio, M.D., Leva, A., Agarwal, A.: SEEC: A general and extensible framework for self-aware computing. Tech. Rep. MIT-CSAIL-TR-2011-046, Computer Science and Artificial Intelligence Laboratory, Massachusetts Institute of Technology (2011)
174. Holland, B., George, A.D., Lam, H., Smith, M.C.: An analytical model for multilevel performance prediction of Multi-FPGA systems. *ACM Transactions on Reconfigurable Technology and Systems* **4**(3), 27–28 (2011)
175. Holland, O., Goodman, R.B.: Robots with internal models: A route to machine consciousness? *Journal of Consciousness Studies* **10**(4), 77–109 (2003)
176. Holopainen, R.: Self-organised sound with autonomous instruments: Aesthetics and experiments. Ph.D. thesis, University of Oslo (2012)
177. Hölzl, M., Wirsing, M.: Towards a system model for ensembles. In: Formal Modeling: Actors, Open Systems, Biological Systems, pp. 241–261. Springer (2011)
178. Hölzl, M., Wirsing, M.: Issues in engineering self-aware and self-expressive ensembles. In: J. Pitt (ed.) *The Computer After Me*, pp. 37–54. Imperial College Press/World Scientific Book (2014)
179. Horn, J., Nafpliotis, N., Goldberg, D.E.: A niched Pareto genetic algorithm for multiobjective optimization. In: Proceedings of the 1st IEEE Conference on Evolutionary Computation, IEEE World Congress on Computational Intelligence, pp. 82–87 (1994)
180. Horn, P.: Autonomic computing: IBM's perspective on the state of information technology. Armonk, NY, USA. International Business Machines Corporation. (2001)
181. Hosseini, M.J., Ahmadi, Z., Beigy, H.: Using a classifier pool in accuracy based tracking of recurring concepts in data stream classification. *Evolving Systems* **4**(1), 43–60 (2013)
182. Hsu, C.H., Feng, W.C.: Reducing overheating-induced failures via performance-aware CPU power management. In: Proceedings of the 6th International Conference on Linux Clusters: The HPC Revolution (2005)
183. Hu, F., Evans, J.J.: Power and environment aware control of Beowulf clusters. *Cluster Computing* **12**, 299–308 (2009)
184. Hu, W., Tan, T., Wang, L., Maybank, S.: A Survey on Visual Surveillance of Object Motion and Behaviors. *IEEE Transactions on Systems, Man and Cybernetics, Part C* **34**(3), 334–352 (2004)
185. Huang, T., Russell, S.: Object Identification in a Bayesian Context. In: Proceedings of the International Joint Conference on Artificial Intelligence, pp. 1276–1283 (1997)
186. Huebscher, M., McCann, J.: Simulation Model for Self-Adaptive Applications in Pervasive Computing. In: Proceedings of the 15th International Workshop on Database and Expert Systems Applications, pp. 694–698. IEEE Computer Society (2004)
187. Hume, D.: *A Treatise of Human Nature*. Gutenberg eBook (1739). URL <http://www.gutenberg.org/ebooks/4705>. (Accessed March 8, 2016)
188. Hunkeler, U., Truong, H.L., Stanford-Clark, A.: MQTT-S-A publish/subscribe protocol for Wireless Sensor Networks. In: Proceedings of the Third International Conference on Communication Systems Software and Middleware and Workshops (COMSWARE), pp. 791–798. IEEE (2008)

189. Hunt, A., Wanderley, M.M., Paradis, M.: The importance of parameter mapping in electronic instrument design. In: Proceedings of the International Conference on New Interfaces for Musical Expression, pp. 1–6. National University of Singapore (2002)
190. IBM: An architectural blueprint for autonomic computing (2003). URL [http://www-03.ibm.com/autonomic/pdfs/AC Blueprint White Paper V7.pdf](http://www-03.ibm.com/autonomic/pdfs/AC%20Blueprint%20White%20Paper%20V7.pdf). (Accessed March 8, 2016)
191. Iglesia, D.: MobMuPlat (iOS application). Iglesia Intermedia (2013)
192. Intel: Sophisticated library for vector parallelism. <http://software.intel.com/en-us/articles/intel-array-building-blocks/>. (Accessed March 8, 2016)
193. Investigating RINA as an Alternative to TCP/IP. URL <http://irati.eu>. (Accessed March 8, 2016)
194. Ishibuchi, H., Murata, T.: A multiobjective genetic local search algorithm and its application to flowshop scheduling. *IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews* **28**(3), 392–403 (1998)
195. Ishibuchi, H., Tsukamoto, N., Nojima, Y.: Iterative approach to indicator-based multiobjective optimization. In: Proceedings of the IEEE Congress on Evolutionary Computation, pp. 3967–3974 (2007)
196. Ishibuchi, H., Tsukamoto, N., Nojima, Y.: Evolutionary many-objective optimization. In: Proceedings of the 3rd International Workshop on Genetic and Evolving Systems (GEFS), pp. 47–52. IEEE (2008)
197. James, W.: The principles of psychology. Henry Holt & Co. (1890)
198. Janusevskis, J., Riche, R.L., Ginsbourger, D., Girdziusas, R.: Expected Improvements for the Asynchronous Parallel Global Optimization of Expensive Functions: Potentials and Challenges. In: Y. Hamadi, M. Schoenauer (eds.) *Learning and Intelligent Optimization*, pp. 413–418. Springer (2012)
199. Javed, O., Khan, S., Rasheed, Z., Shah, M.: Camera Handoff: Tracking in Multiple Uncalibrated Stationary Cameras. In: Proceedings of the Workshop on Human Motion, pp. 113–118. IEEE Computer Society Press (2000). DOI 10.1109/HUMO.2000.897380
200. Javed, O., Rasheed, Z., Shafique, K., Shah, M.: Tracking across Multiple Cameras Disjoint Views. In: Proceedings of IEEE International Conference on Computer Vision, p. 952–957 (2003)
201. Jia, J., Veeravalli, B., Ghose, D.: Adaptive load distribution strategies for divisible load processing on resource unaware multilevel tree networks. *IEEE Transactions on Computers* **56**(7), 999–1005 (2007)
202. Jin, Q., Becker, T., Luk, W., Thomas, D.: Optimising explicit finite difference option pricing for dynamic constant reconfiguration. In: Proceedings of the International Conference on Field Programmable Logic and Applications (FPL), pp. 165–172 (2012)
203. Jin, Y., Olhofer, M., Sendhoff, B.: A framework for evolutionary optimization with approximate fitness functions. *IEEE Transactions on Evolutionary Computation* **6**(5), 481–494 (2002)
204. Jones, D.R., Schonlau, M., Welch, W.J.: Efficient global optimization of expensive black-box functions. *Journal of Global Optimization* **13**(4), 455–492 (1998)
205. Jones, P., Cho, Y., Lockwood, J.: Dynamically optimizing FPGA applications by monitoring temperature and workloads. In: Proceedings of the International Conference on VLSI Design (VLSID). IEEE (2007)
206. Kalal, Z., Mikolajczyk, K., Matas, J.: Tracking-Learning-Detection. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **34**(7), 1409–1422 (2012)
207. Kalman, R.E.: A New Approach to Linear Filtering and Prediction Problems. *Journal of Fluids Engineering* **82**(1), 35–45 (1960)
208. Kamil, S., Chan, C., Olike, L., Shalf, J., Williams, S.: An auto-tuning framework for parallel multicore stencil computations. In: Proceedings of the IEEE International Symposium on Parallel & Distributed Processing (IPDPS), pp. 1–12 (2010)
209. Kang, J., Cohen, I., Medioni, G.: Continuous Tracking within and across Camera Streams. In: Proceedings of IEEE Conference on Computer Vision and Pattern Recognition, pp. 267–272 (2003)

210. Kant, I.: The critique of pure reason. Gutenberg eBook (1781). URL <http://www.gutenberg.org/ebooks/4280>. Digital edition 2003 (Accessed March 8, 2016)
211. Kela, J., Korpipää, P., Mäntyjärvi, J., Kallio, S., Savino, G., Jozzo, L., Marca, D.: Accelerometer-based gesture control for a design environment. *Personal and Ubiquitous Computing* **10**(5), 285–299 (2006)
212. Keller, A., Borkmann, D., Neuhaus, S., Happe, M.: Self-Awareness in Computer Networks. *International Journal of Reconfigurable Computing* pp. 1–10 (2014). DOI 10.1155/2014/692076
213. Kephart, J.O., Chess, D.M.: The Vision of Autonomic Computing. *IEEE Computer* **36**(1), 41–50 (2003)
214. Kettner, V., Zabith, R.: Bayesian Multi-Camera Surveillance. In: Proceedings of the International Conference on Computer Vision and Pattern Recognition, pp. 117–123 (1999)
215. Khan, M.I., Rinner, B.: Energy-aware task scheduling in wireless sensor networks based on cooperative reinforcement learning. In: Proceedings of the International Conference on Communications Workshops (ICCW). IEEE (2014). DOI 10.1109/ICCW.2014.6881310
216. Khare, V., Yao, X., Deb, K.: Performance scaling of multi-objective evolutionary algorithms. In: Evolutionary Multi-Criterion Optimization, Lecture Notes in Computer Science, vol. 2632, pp. 376–390. Springer (2003)
217. Kim, H.S., Sherman, D.K.: Express yourself: Culture and the effect of self-expression on choice. *Journal of Personality and Social Psychology* **92**(1), 1–11 (2007). DOI 10.1037/0022-3514.92.1.1
218. Kim, J., Seo, S., Lee, J., Nah, J., Jo, G., Lee, J.: OpenCL as a unified programming model for heterogeneous CPU/GPU clusters. In: Proceedings of the 17th ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming (PPOPP), pp. 299–300 (2012)
219. Kittler, J., Hatef, M., Duin, R.P., Matas, J.: On combining classifiers. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **20**(3), 226–239 (1998)
220. Klinglmayr, J., Bettstetter, C.: Self-organizing synchronization with inhibitory-coupled oscillators: Convergence and robustness. *ACM Transactions on Autonomous and Adaptive Systems* **7**(3), 30:1–30:22 (2012)
221. Klinglmayr, J., Kirst, C., Bettstetter, C., Timme, M.: Guaranteeing global synchronization in networks with stochastic interactions. *New Journal of Physics* **14**(7), 1–13 (2012)
222. Knutzen, H., Nymoen, K., Torresen, J.: PheroMusic [iOS application]. URL <http://itunes.apple.com/app/pheromusic/id910100415>
223. Kolter, J.Z., Maloof, M.A.: Dynamic weighted majority: An ensemble method for drifting concepts. *Journal of Machine Learning Research* **8**, 2755–2790 (2007)
224. Koski, J., Silvennoinen, R.: Norm methods and partial weighting in multicriterion optimization of structures. *International Journal for Numerical Methods in Engineering* **24**(6), 1101–1121 (1987)
225. Kramer, J., Magee, J.: Self-managed systems: an architectural challenge. In: Future of Software Engineering (FoSE), pp. 259–268. IEEE (2007)
226. Krishnamoorthy, S., Baskaran, M., Bondhugula, U., Ramanujam, J., Rountev, A., Sadayappan, P.: Effective automatic parallelization of stencil computations. In: Proceedings of the 28th ACM SIGPLAN Conference on Programming Language Design and Implementation, pp. 235–244 (2007)
227. Kuhn, H.W., Yaw, B.: The Hungarian Method for the Assignment Problem. *Naval Research Logistics Quarterly* pp. 83–97 (1955)
228. Kuncheva, L.I.: A theoretical study on six classifier fusion strategies. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **24**(2), 281–286 (2002)
229. Kurek, M., Becker, T., Chau, T.C., Luk, W.: Automating Optimization of Reconfigurable Designs. In: Proceedings of the International Symposium on Field-Programmable Custom Computing Machines (FCCM), pp. 210–213. IEEE (2014). DOI 10.1109/FCCM.2014.65
230. Kurek, M., Becker, T., Luk, W.: Parametric Optimization of Reconfigurable Designs Using Machine Learning. In: Proceedings of the International Conference on Reconfigurable Computing: Architectures, Tools and Applications (ARC), *Lecture Notes in Computer Science*, vol. 7806, pp. 134–145. Springer (2013)

231. Legrain, L., Cleeremans, A., Destrebecqz, A.: Distinguishing three levels in explicit self-awareness. *Consciousness and Cognition* **20**, 578–585 (2011)
232. Legrand, D.: Pre-reflective self-as-subject from experiential and empirical perspectives. *Consciousness and Cognition* **16**(3), 583–599 (2007)
233. Leidenfrost, R., Elmenreich, W.: Firefly clock synchronization in an 802.15.4 wireless network. *EURASIP Journal on Embedded Systems* **2009**, 7:1–7:17 (2009)
234. Leland, W., Taqqu, M., Willinger, W., Wilson, D.: On the self-similar nature of ethernet traffic (extended version). *IEEE/ACM Transactions on Networking* **2**(1), 1–15 (1994). DOI 10.1109/90.282603
235. Leutenegger, S., Chli, M., Siegwart, R.Y.: BRISK: Binary robust invariant scalable keypoints. In: *Proceedings of the International Conference on Computer Vision*, pp. 2548–2555. IEEE (2011). DOI 10.1109/iccv.2011.6126542
236. Lewis, P.R., Chandra, A., Faniyi, F., Glette, K., Chen, T., Bahsoon, R., Torresen, J., Yao, X.: Architectural aspects of self-aware and self-expressive computing systems: From psychology to engineering. *IEEE Computer* **48**(8), 62–70 (2015)
237. Lewis, P.R., Chandra, A., Parsons, S., Robinson, E., Glette, K., Bahsoon, R., Torresen, J., Yao, X.: A Survey of Self-Awareness and Its Application in Computing Systems. In: *Proceedings of the International Conference on Self-Adaptive and Self-Organizing Systems Workshops (SASOW)*, pp. 102–107. IEEE Computer Society, Ann Arbor, MI, USA (2011)
238. Lewis, P.R., Esterle, L., Chandra, A., Rinner, B., Torresen, J., Yao, X.: Static, Dynamic, and Adaptive Heterogeneity in Distributed Smart Camera Networks. *ACM Transactions on Autonomous and Adaptive Systems* **10**(2), 8:1–8:30 (2015). DOI 10.1145/2764460
239. Lewis, P.R., Esterle, L., Chandra, A., Rinner, B., Yao, X.: Learning to be Different: Heterogeneity and Efficiency in Distributed Smart Camera Networks. In: *Proceedings of the International Conference on Self-Adaptive and Self-Organizing Systems (SASO)*, pp. 209–218. IEEE Computer Society Press (2013). DOI 10.1109/SASO.2013.20
240. Lewis, P.R., Marrow, P., Yao, X.: Resource Allocation in Decentralised Computational Systems: An Evolutionary Market Based Approach. *Autonomous Agents and Multi-Agent Systems* **21**(2), 143–171 (2010)
241. Lewis, P.R., Platzner, M., Yao, X.: An outlook for self-awareness in computing systems. *Awareness Magazine* (2012). DOI 10.2417/3201203.004093
242. Li, B., Li, J., Tang, K., Yao, X.: An improved Two Archive Algorithm for Many-Objective Optimization. In: *Proceedings of the IEEE Congress on Evolutionary Computation (CEC)*, pp. 2869–2876 (2014)
243. Li, G., Gopalakrishnan, G.: Scaleable SMT-based verification of GPU kernel functions. In: *Proceedings of the Eighteenth International Symposium on the Foundations of Software Engineering (FSE-18)* (2010)
244. Li, H., Zhang, Q.: Multiobjective optimization problems with complicated Pareto sets, MOEA/D and NSGA-II. *IEEE Transactions on Evolutionary Computation* **13**(2), 284–302 (2009)
245. Li, Y., Bhanu, B.: Utility-based Camera Assignment in a Video Network: A Game Theoretic Framework. *Sensors Journal* **11**(3), 676–687 (2011)
246. Liang, C.J.M., Liu, J., Luo, L., Terzis, A., Zhao, F.: RACNet: A High-Fidelity Data Center Sensing Network. *Proceedings of the 7th ACM Conference on Embedded Networked Sensor Systems* pp. 15–28 (2009)
247. Liu, J., Zhong, L., Wickramasuriya, J., Vasudevan, V.: uWave: Accelerometer-based personalized gesture recognition and its applications. *Pervasive and Mobile Computing* **5**(6), 657–675 (2009)
248. Liu, Y., Yao, X.: Ensemble learning via negative correlation. *Neural Networks* **12**(10), 1399–1404 (1999)
249. Lübbers, E., Platzner, M.: Cooperative multithreading in dynamically reconfigurable systems. In: *Proceedings of the International Conference on Field Programmable Logic and Applications (FPL)*, pp. 1–4. IEEE (2009)
250. Lübbers, E., Platzner, M.: ReconOS: Multithreaded programming for reconfigurable computers. *ACM Transactions on Embedded Computing Systems* **9** (2009)

251. Lucas, B.D., Kanade, T.: An iterative image registration technique with an application to stereo vision. In: Proceedings of the International Joint Conference on Artificial Intelligence (IJCAI), pp. 674–679 (1981)
252. Maggio, M., Hoffmann, H., Santambrogio, M.D., Agarwal, A., Leva, A.: A comparison of autonomic decision making techniques. Tech. Rep. MIT-CSAIL-TR-2011-019, Computer Science and Artificial Intelligence Laboratory, Massachusetts Institute of Technology (2011)
253. Makris, D., Ellis, T., Black, J.: Bridging the Gaps between Cameras. In: Proceedings of Conference on Computer Vision and Pattern Recognition, vol. 2 (2004)
254. Marler, R.T., Arora, J.S.: Function-transformation methods for multi-objective optimization. *Engineering Optimization* **37**(6), 551–570 (2005)
255. Marrow, P.: Nature-inspired computing technology and applications. *BT Technology Journal* **18**(4), 13–23 (2000)
256. Marsaglia, G., Bray, T.A.: A convenient method for generating normal variables. *SIAM Review* **6**(3), 260–264 (1964)
257. Masahiro, N., Takaesu, H., Demachi, H., Oono, M., Saito, H.: Development of an automatic music selection system based on runner’s step frequency. In: Proceedings of the 2008 International Conference on Music Information Retrieval, pp. 193–8 (2008)
258. Massie, M.L., Chun, B.N., Culler, D.E.: The Ganglia distributed monitoring system: design, implementation, and experience. *Parallel Computing* **30**, 817–840 (2004)
259. Mathar, R., Mattfeldt, J.: Pulse-coupled decentral synchronization. *SIAM Journal on Applied Mathematics* **56**(4), 1094–1106 (1996)
260. Max [computer software]. URL <http://cycling74.com>. (Accessed March 8, 2016)
261. McKay, M.D., Beckman, R.J., Conover, W.J.: A comparison of three methods for selecting values of input variables in the analysis of output from a computer code. *Technometrics* pp. 55–61 (2000)
262. Mehta, N.R., Medvidovic, N.: Composing architectural styles from architectural primitives. In: Proceedings of the European Software Engineering Conference and ACM SIGSOFT Symposium on the Foundations of Software Engineering, pp. 347–350 (2003). URL <http://dblp.uni-trier.de/db/conf/signsoft/fse2003.html#MehtaM03>
263. Menasce, D.A., Sousa, J.a.P., Malek, S., Gomaa, H.: QoS Architectural Patterns for Self-architecting Software Systems. In: Proceedings of the 7th International Conference on Autonomic Computing (ICAC), pp. 195–204. ACM (2010). DOI 10.1145/1809049.1809084
264. Metcalfe, J., Shimamura, A.P. (eds.): *Metacognition: Knowing about knowing*. MIT Press, Cambridge, MA, USA (1994)
265. Michalski, R.S.: A Theory and Methodology of Inductive Learning. In: *Machine Learning, Symbolic Computation*, pp. 83–134. Springer Berlin Heidelberg (1983)
266. Miettinen, K., Mäkelä, M.M.: Interactive bundle-based method for nondifferentiable multi-objective optimization: nimbus. *Optimization Journal* **34**(3), 231–246 (1995)
267. Minku, L.L.: Online ensemble learning in the presence of concept drift. Ph.D. thesis, School of Computer Science, University of Birmingham, Birmingham, UK (2010)
268. Minku, L.L., Yao, X.: DDD: A new ensemble approach for dealing with concept drift. *IEEE Transactions on Knowledge and Data Engineering* **24**(4), 619–633 (2012)
269. Minku, L.L., Yao, X.: Software Effort Estimation as a Multi-objective Learning Problem. *ACM Transactions on Software Engineering and Methodology* **22**(4), 35:1–32 (2013)
270. Miranda, E.R., Wanderley, M.: *New Digital Musical Instruments: Control and Interaction Beyond the Keyboard*. A-R Editions, Inc., Middleton, WI (2006)
271. Mirollo, R.E., Strogatz, S.H.: Synchronization of pulse-coupled biological oscillators. *SIAM Journal on Applied Mathematics* **50**(6), 1645–1662 (1990)
272. Mitchell, M.: Self-awareness and control in decentralized systems. In: Proceedings of the AAAI Spring Symposium on Metacognition in Computation (2005). Available at <http://www.cs.pdx.edu/mm/self-awareness.pdf>
273. Modler, P.: Neural networks for mapping hand gestures to sound synthesis parameters, vol. 18, p. 14. IRCAM — Centre Pompidou (2000)

274. Moens, B., van Noorden, L., Leman, M.: D-Jogger: Syncing music with walking. In: Proceedings of the Sound and Music Computing Conference, pp. 451–456. Barcelona, Spain (2010)
275. Morin, A.: Levels of consciousness and self-awareness: A comparison and integration of various neurocognitive views. *Consciousness and Cognition* **15**(2), 358–71 (2006)
276. Morin, A., Everett, J.: Conscience de soi et langage interieur: Quelques speculations. [Self-awareness and inner speech: Some speculations]. *Philosophiques* **XVII**(2), 169–188 (1990)
277. Müller-Schloer, C., Schmeck, H., Ungerer, T.: Organic computing: a paradigm shift for complex systems. Springer (2011)
278. Nakashima, H., Aghajan, H., Augusto, J.C.: Handbook of ambient intelligence and smart environments. Springer (2009)
279. Narukawa, K., Tanigaki, Y., Ishibuchi, H.: Evolutionary many-objective optimization using preference on hyperplane. In: Proceedings of the 2014 Conference on Genetic and Evolutionary Computation Companion, pp. 91–92. ACM (2014)
280. Natarajan, P., Atrey, P.K., Kankanhalli, M.: Multi-camera coordination and control in surveillance systems: A survey. *ACM Transactions on Multimedia Computing, Communications and Applications* **11**(4), 57:1–57:30 (2015). DOI 10.1145/2710128
281. Nebehay, G., Chibamu, W., Lewis, P.R., Chandra, A., Pflugfelder, R., Yao, X.: Can diversity amongst learners improve online object tracking? In: Z.H. Zhou, F. Roli, J. Kittler (eds.) *Multiple Classifier Systems, Lecture Notes in Computer Science*, vol. 7872, pp. 212–223. Springer (2013). DOI 10.1007/978-3-642-38067-9_19
282. Nebehay, G., Pflugfelder, R.: Consensus-based matching and tracking of keypoints for object tracking. In: Proceedings of the Winter Conference on Applications of Computer Vision (WACV). IEEE (2014)
283. Nebro, A.J., Luna, F., Alba, E., Beham, A., Dorronsoro, B.: AbYSS: adapting scatter search for multiobjective optimization. Tech. Rep. ITI-2006-2, Departamento de Lenguajes y Ciencias de la Computación, University of Málaga, Malaga (2006)
284. Neisser, U.: The Roots of Self-Knowledge: Perceiving Self, It, and Thou. *Annals of the NY AoS*. **818**, 19–33 (1997)
285. netem. URL <http://www.linuxfoundation.org/collaborate/workgroups/networking/netem>. (Accessed March 8, 2016)
286. Nguyen, A., Satish, N., Chhugani, J., Kim, C., Dubey, P.: 3.5-D blocking optimization for stencil computations on modern CPUs and GPUs. In: Proceedings of the ACM/IEEE International Conference for High Performance Computing, Networking, Storage and Analysis, pp. 1–13 (2010)
287. Niezen, G., Hancke, G.P.: Evaluating and optimising accelerometer-based gesture recognition techniques for mobile devices. In: Proceedings of AFRICON, pp. 1–6. IEEE (2009)
288. Nishida, K.: Learning and detecting concept drift. Ph.D. thesis, Hokkaido University (2008). URL <http://lis2.huie.hokudai.ac.jp/~knishida/paper/nishida2008-dissertation.pdf>
289. Nishida, K., Yamauchi, K.: Detecting concept drift using statistical testing. In: Proceedings of the Tenth International Conference on Discovery Science (DS) - Lecture Notes in Artificial Intelligence, vol. 3316, pp. 264–269. Sendai, Japan (2007)
290. Niu, X., Chau, T.C.P., Jin, Q., Luk, W., Liu, Q.: Automating elimination of idle functions by run-time reconfiguration. In: Proceedings of the 21st IEEE Annual International Symposium on Field-Programmable Custom Computing Machines (FCCM), pp. 97–104 (2013)
291. Niu, X., Coutinho, J.G.F., Luk, W.: A scalable design approach for stencil computation on reconfigurable clusters. In: Proceedings of the 23rd International Conference on Field programmable Logic and Applications (FPL), pp. 1–4 (2013)
292. Niu, X., Jin, Q., Luk, W., Liu, Q., Pell, O.: Exploiting run-time reconfiguration in stencil computation. In: Proceedings of the 22nd International Conference on Field programmable Logic and Applications (FPL), pp. 173–180 (2012)
293. Niu, X., Tsoi, K.H., Luk, W.: Reconfiguring distributed applications in FPGA accelerated cluster with wireless networking. In: Proceedings of the 21st International Conference on Field Programmable Logic and Applications (FPL), pp. 545–550 (2011)

294. NVIDIA: Cuda zone. http://www.nvidia.com/object/cuda_home_new.html. (Accessed March 8, 2016)
295. Nymoen, K., Chandra, A., Glette, K., Torresen, J.: Decentralized harmonic synchronization in mobile music systems. In: Proceedings of the International Conference on Awareness Science & Technology (iCAST), pp. 1–6 (2014)
296. Nymoen, K., Chandra, A., Glette, K., Torresen, J., Voldsund, A., Jensenius, A.R.: Phero-Music: Navigating a Musical Space for Active Music Experiences. In: Proceedings of the International Computer Music Conference (ICMC) joint with the Sound and Music Computing Conference, pp. 1715–1718 (2014)
297. Nymoen, K., Song, S., Hafting, Y., Torresen, J.: Funky Sole Music: Gait recognition and adaptive mapping. In: Proceedings of the International Conference on New Interfaces for Musical Expression (NIME), pp. 299–302 (2014)
298. Okuma, K., Taleghani, A., de Freitas, N., Little, J., Lowe, D.: A Boosted Particle Filter: Multitarget Detection and Tracking. In: Proceedings of 8th European Conference on Computer Vision, vol. 3021, pp. 28–39 (2004)
299. Olfati-Saber, R.: Distributed Kalman filtering for sensor networks. In: Proceedings of the Conference on Decision and Control, pp. 5492–5498 (2007). DOI 10.1109/CDC.2007.4434303
300. Olsson, R.A., Keen, A.W.: Remote procedure call. The JR Programming Language: Concurrent Programming in an Extended Java pp. 91–105 (2004)
301. Ong, Y.S., Nair, P.B., Keane, A.J.: Evolutionary optimization of computationally expensive problems via surrogate modeling. *AIAA Journal* **41**(4), 689–696 (2003)
302. Ontañón, S., Plaza, E.: Multiagent Inductive Learning: An Argumentation-based Approach. In: J. Fürnkranz, T. Joachims (eds.) Proceedings of the 27th International Conference on Machine Learning (ICML), pp. 839–846. Omnipress, Haifa, Israel (2010)
303. Oxford: Oxford dictionaries: Adapt. <http://www.oxforddictionaries.com/definition/english/adapt>. (Accessed March 8, 2016)
304. Oza, N.C.: Online bagging and boosting. In: Proceedings of the IEEE International Conference on Systems, Man and Cybernetics, pp. 2340–2345 (2005)
305. Oza, N.C., Russell, S.: Experimental comparisons of online and batch versions of bagging and boosting. In: Proceedings of the seventh ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, pp. 359–364 (2001)
306. Özyusal, M., Calonder, M., Lepetit, V., Fua, P.: Fast Keypoint Recognition Using Random Ferns. *IEEE Transactions on Pattern Analysis and Machine Intelligence* **32**(3), 448–461 (2010). DOI 10.1109/tpami.2009.23
307. Page, I., Luk, W.: Compiling occam into Field-Programmable Gate Arrays. In: Proceedings of the International Conference on Field programmable Logic and Applications (FPL) (1991)
308. Papakonstantinou, A., Liang, Y., Stratton, J.A., Gururaj, K., Chen, D., Hwu, W.W., Cong, J.: Multilevel Granularity Parallelism Synthesis on FPGAs. In: Proceedings of the 19th Annual International Symposium on Field-Programmable Custom Computing Machines (FCCM), pp. 178–185. IEEE (2011)
309. Parashar, M., Hariri, S.: Autonomic computing: an overview. In: Proceedings of the International Conference on Unconventional Programming Paradigms, pp. 257–269. Springer-Verlag, Berlin (2005)
310. Parsons, S., Bahsoon, R., Lewis, P.R., Yao, X.: Towards a better understanding of self-awareness and self-expression within software systems. Tech. Rep. CSR-11-03, University of Birmingham, School of Computer Science, UK (2011)
311. Paul, C., Bass, L., Kazman, R.: *Software Architecture in Practice*. MA: Addison-Wesley (1998)
312. Paul, C., Kazman, R., Klein, M.: *Evaluating Software Architectures: Methods and Case Studies*. Addison-Wesley (2002)
313. Paulson, L.: DARPA creating self-aware computing. *IEEE Computer* **36**(3), 24 (2003). DOI 10.1109/MC.2003.1185213
314. Peleg, A., Wilkie, S., Weiser, U.C.: Intel MMX for Multimedia PCs. *Communications of the ACM* **40**(1), 24–38 (1997)

315. Perkowit, M., Philipose, M., Fishkin, K., Patterson, D.J.: Mining models of human activities from the Web. In: Proceedings of the 13th International Conference on World Wide Web, pp. 573–582 (2004)
316. Perrone, M., Liu, L.K., Lu, L., Magerlein, K., Kim, C., Fedulova, I., Semenikhin, A.: Reducing Data Movement Costs: Scalable Seismic Imaging on Blue Gene. In: Proceedings of the 26th International Parallel & Distributed Processing Symposium (IPDPS), pp. 320–329 (2012)
317. Perrone, M.P., Cooper, L.N.: When networks disagree: Ensemble methods for hybrid neural networks. *Neural Networks for Speech and Image Processing*, Chapman-Hall, New York pp. 126–142 (1993)
318. Peskin, C.S.: *Mathematical aspects of heart physiology*. Courant Institute of Mathematical Sciences, New York University New York (1975)
319. Pflugfelder, R., Bischof, H.: People Tracking across Two Distant Self-calibrated Cameras. In: Proceedings of International Conference on Advanced Video and Signal-based Surveillance. IEEE Computer Society Press (2006)
320. Pflugfelder, R., Bischof, H.: Tracking across Non-overlapping Views Via Geometry. In: Proceedings of the International Conference on Pattern Recognition (2008)
321. Phelps, S., McBurney, P., Parsons, S.: Evolutionary mechanism design: A review. *Autonomous Agents and Multi-Agent Systems* **21**(2), 237–264 (2010)
322. Piciarelli, C., Esterle, L., Khan, A., Rinner, B., Foresti, G.: Dynamic Reconfiguration in Camera Networks: a short survey. *IEEE Transactions on Circuits and Systems for Video Technology* **PP**(99), 1–13 (2015). DOI 10.1109/TCSVT.2015.2426575. (early access)
323. Pilato, C., Loiacono, D., Tumeo, A., Ferrandi, F., Lanzi, P.L., Sciuto, D.: Speeding-up expensive evaluations in highlevel synthesis using solution modeling and fitness inheritance. In: Y. Tenne, C.K. Goh (eds.) *Computational Intelligence in Expensive Optimization Problems*, vol. 2, pp. 701–723. Springer (2010)
324. Polikar, R.: Ensemble based systems in decision making. *IEEE Circuits and Systems Magazine* **6**(3), 21–45 (2006)
325. Polikar, R., Udpa, L., Udpa, S., Honavar, V.: Learn++: An incremental learning algorithm for supervised neural networks. *IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews* **31**(4), 497–508 (2001)
326. Puckette, M.: Pure Data (PD) (software). URL <http://puredata.info>. (Accessed March 8, 2016)
327. Pylvänäinen, T.: Accelerometer based gesture recognition using continuous HMMs. In: *Pattern Recognition and Image Analysis*, pp. 639–646. Springer (2005)
328. Quaritsch, M., Kreuzthaler, M., Rinner, B., Bischof, H., Strobl, B.: Autonomous Multicamera Tracking on Embedded Smart Cameras. *EURASIP Journal on Embedded Systems* **2007**(1), 35–45 (2007)
329. Rajko, S., Qian, G., Ingalls, T., James, J.: Real-time gesture recognition with minimal training requirements and on-line learning. In: Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 1–8. IEEE (2007)
330. Ramamurthy, S., Bhatnagar, R.: Tracking recurrent concept drift in streaming data using ensemble classifiers. In: Proceedings of the Sixth International Conference on Machine Learning and Applications (ICMLA), pp. 404–409. Cincinnati, Ohio (2007)
331. Rammer, I., Szpuszta, M.: *Advanced .NET Remoting*. Springer (2005)
332. Ramos, C., Augusto, J.C., Shapiro, D.: Ambient intelligence - the next step for artificial intelligence. *IEEE Intelligent Systems* **23**(2), 15–18 (2008). DOI 10.1109/MIS.2008.19
333. Rasmussen, C., Williams, C.: *Gaussian Processes for Machine Learning*. MIT Press (2006)
334. Reason [computer software]. URL <https://www.propellerheads.se>. (Accessed March 8, 2016)
335. ReconOS: A programming model and OS for reconfigurable hardware (2013). URL <http://www.reconos.de/>. (Accessed March 8, 2016)
336. Reisslein, M., Rinner, B., Roy-Chowdhury, A.: Smart camera networks. *IEEE Computer* **47**(5), 26–28 (2014)
337. Reyes, R., de Sande, F.: Automatic code generation for gpus in llc. *The Journal of Supercomputing* **58**(3), 349–356 (2011)

338. Richter, U., Mnif, M., Branke, J., Müller-Schloer, C., Schmeck, H.: Towards a generic observer/controller architecture for organic computing. In: C. Hochberger, R. Liskowsky (eds.) *INFORMATIK 2006 – Informatik für Menschen, LNI*, vol. P-93, pp. 112–119. Bonner Köllen Verlag (2006)
339. Rietmann, M., Messmer, P., Nissen-Meyer, T., Peter, D., Basini, P., Komatitsch, D., Schenk, O., Tromp, J., Boschi, L., Giardini, D.: Forward and adjoint simulations of seismic wave propagation on emerging large-scale GPU architectures. In: *Proceedings of the Conference on High Performance Computing Networking, Storage and Analysis (SC) (2012)*
340. Rinner, B., Esterle, L., Simonjan, J., Nebehay, G., Pflugfelder, R., Fernandez, G., Lewis, P.R.: Self-Aware and Self-Expressive Camera Networks. *IEEE Computer* **48**(7), 33–40 (2015)
341. Rinner, B., Winkler, T., Schriebl, W., Quaritsch, M., Wolf, W.: The evolution from single to pervasive smart cameras. In: *Proceedings of the Second ACM/IEEE International Conference on Distributed Smart Cameras (ICDSC)*, pp. 1–10 (2008). DOI 10.1109/ICDSC.2008.4635674
342. Rinner, B., Wolf, W.: Introduction to Distributed Smart Cameras. *Proceedings of the IEEE* **96**(10), 1565–1575 (2008). DOI 10.1109/JPROC.2008.928742
343. RNA: Recursive Network Architecture. URL <http://www.isi.edu/rna>. (Accessed March 8, 2015)
344. Rochat, P.: Five levels of self-awareness as they unfold in early life. *Consciousness and Cognition* **12**, 717–731 (2003)
345. Russell, S.J., Norvig, P.: *Artificial Intelligence - A Modern Approach*, 3 edn. Pearson Education (2010)
346. Saaty, T.L.: *The Analytical Hierarchical Process*. McGraw-Hill (1980)
347. Sakellari, G.: The cognitive packet network: A survey. *The Computer Journal* **53** (2010)
348. SanMiguel, J.C., Shoop, K., Cavallaro, A., Micheloni, C., Foresti, G.L.: Self-Reconfigurable Smart Camera Networks. *IEEE Computer* **47**(5), 67–73 (2014)
349. Santambrogio, M., Hoffmann, H., Eastep, J., Agarwal, A.: Enabling technologies for self-aware adaptive systems. In: *2010 NASA/ESA Conference on Adaptive Hardware and Systems (AHS)*, pp. 149–156. IEEE (2010)
350. Santner, J., Leistner, C., Saffari, A., Pock, T., Bischof, H.: PROST: Parallel robust online simple tracking. In: *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 723–730 (2010)
351. Schaumeier, J., Jeremy Pitt, J., Cabri, G.: A tripartite analytic framework for characterising awareness and self-awareness in autonomic systems research. In: *Proceedings of the Sixth IEEE Conference on Self-Adaptive and Self-Organizing Systems Workshops (SASOW)*, pp. 157–162 (2012)
352. Schlömer, T., Poppinga, B., Henze, N., Boll, S.: Gesture recognition with a Wii controller. In: *Proceedings of the 2nd International Conference on Tangible and Embedded Interaction*, pp. 11–14. ACM (2008)
353. Schmeck, H.: Organic computing - a new vision for distributed embedded systems. In: *Proceedings of the Eighth IEEE International Symposium on Object-Oriented Real-Time Distributed Computing (ISORC)*, pp. 201–203 (2005)
354. Schmickl, T., Thenius, R., Moslinger, C., Timmis, J., Tyrrell, A., Read, M., Hilder, J., Halloy, J., Campo, A., Stefanini, C., Manfredi, L., Orofino, S.: CoCoRo—The Self-Aware Underwater Swarm. In: *Proceedings of the International Conference on Self-Adaptive and Self-Organizing Systems Workshops (SASOW)*, pp. 120–126. IEEE Computer Society, Ann Arbor, MI, USA (2011)
355. Schmier, T., Yao, X.: Using negative correlation to evolve fault-tolerant circuits. In: *Proceedings of the 5th International Conference on Evolvable Systems: From Biology to Hardware (ICES'2003) – Lecture Notes in Computer Science*, vol. 2606, pp. 35–46. Springer-Verlag (2003)
356. Scholz, M., Klinkenberg, R.: Boosting classifiers for drifting concepts. *Intelligent Data Analysis* **11**(1), 3–28 (2007)
357. Sharan, K.: Java remote method invocation. In: *Beginning Java 8 APIs, Extensions and Libraries*, chap. 7, pp. 525–548. Springer (2014)

358. Shaw, M.J., Sikora, R.: A distributed problem-solving approach to inductive learning. Tech. Rep. CMU-RI-TR-90-262, School of Computer Science, Carnegie Mellon University (1990)
359. Shipp, C.A., Kuncheva, L.I.: Relationships between combination methods and measures of diversity in combining classifiers. *Information Fusion* **3**(2), 135–148 (2002)
360. Showerman, M., Enos, J., Pant, A., Kindratenko, V., Steffen, C., Pennington, R., mei Hwu, W.: QP: A heterogeneous multi-accelerator cluster. In: Proceedings of the International Conference on High-Performance Clustered Computing (2009)
361. Shukla, S.K., Yang, Y., Bhuyan, L.N., Brisk, P.: Shared memory heterogeneous computation on PCIe-supported platforms. In: Proceedings of the 23rd International Conference on Field programmable Logic and Applications (FPL), pp. 1–4 (2013)
362. Simonjan, J., Esterle, L., Rinner, B., Nebehay, G., Dominguez, G.F.: Demonstrating autonomous handover in heterogeneous multi-camera systems. In: Proceedings of the International Conference on Distributed Smart Cameras, pp. 43:1–43:3 (2014). DOI 10.1145/2659021.2669474
363. Sironi, F., Bartolini, D.B., Campanoni, S., Cancare, F., Hoffmann, H., Sciuto, D., Santambrogio, M.D.: Metronome: Operating System Level Performance Management via Self-adaptive Computing. In: Proceedings of the Design Automation Conference (DAC). ACM (2012)
364. Sironi, F., Cuoccio, A., Hoffmann, H., Maggio, M., Santambrogio, M.: Evolvable Systems on Reconfigurable Architecture via Self-aware Adaptive Applications. In: Proceedings of the NASA/ESA Conference on Adaptive Hardware and Systems (AHS) (2011). DOI 10.1109/AHS.2011.5963933
365. Sironi, F., Triverio, M., Hoffmann, H., Maggio, M., Santambrogio, M.: Self-aware Adaptation in FPGA-based Systems. In: Proceedings of the International Conference on Field Programmable Logic and Applications. IEEE (2010)
366. Smallwood, J., McSpadden, M., Schooler, J.: The lights are on but no one’s home: meta-awareness and the decoupling of attention when the mind wanders. *Psychonomic Bulletin and Review* **14**(3), 527–533 (2007)
367. Song, S., Chandra, A., Torresen, J.: An ant learning algorithm for gesture recognition with one-instance training. In: Proceedings of the International Congress on Evolutionary Computation (CEC), pp. 2956–2963. IEEE (2013)
368. SRC Computers, L.: SRC-7 MAPstation. Tech. rep., SRC Computers (2009)
369. Srinivas, N., Deb, K.: Multiobjective optimization using nondominated sorting in genetic algorithms. *Evolutionary Computation* **2**(3), 221–248 (1994)
370. Stanley, K.O.: Learning concept drift with a committee of decision trees. Tech. Rep. UT-AI-TR-03-302, Department of Computer Sciences, University of Texas at Austin (2003)
371. Sterritt, R., Parashar, M., Tianfield, H., Unland, R.: A concise introduction to autonomic computing. *Advanced Engineering Informatics* **19**(3), 181–187 (2005)
372. Steuer, R.E., Choo, E.U.: An interactive weighted Tchebycheff procedure for multiple objective programming. *Mathematical Programming* **26**(3), 326–344 (1983)
373. Stone, P.: Layered Learning in Multiagent Systems: A Winning Approach to Robotic Soccer. MIT Press (2000)
374. Strassen, V.: Gaussian elimination is not optimal. *Numerische Mathematik* pp. 13:354–356 (1969)
375. Street, W., Kim, Y.: A streaming ensemble algorithm (SEA) for large-scale classification. In: Proceedings of the Seventh ACM International Conference on Knowledge Discovery and Data Mining (KDD), pp. 377–382. New York (2001)
376. Strenski, D.: The Cray XD1 computer and its reconfigurable architecture. Tech. rep., Cray Inc. (2005)
377. Strey, A., Bange, M.: Performance Analysis of Intel’s MMX and SSE: A Case Study. In: Proceedings of 7th International Euro-Par Conference on Parallel Processing (Euro-Par), pp. 142–147. Manchester, UK (2001)
378. Susanto, K.W., Todman, T., Coutinho, J.G.F., Luk, W.: Design Validation by Symbolic Simulation and Equivalence Checking: A Case Study in Memory Optimization for Image Manipulation, *LNCS*, vol. 5404, pp. 509–520. Springer (2009)

379. Sutter, H.: The free lunch is over: A fundamental turn toward concurrency in software. *Dr. Dobbs's Journal* (2005)
380. Sutton, R.S., Barto, A.G.: *Reinforcement Learning: An Introduction*. MIT Press (1998)
381. Taj, M., Cavallaro, A.: Distributed and decentralized multi-camera tracking. *IEEE Signal Processing Magazine* **28**(3), 46–58 (2011)
382. Tawney, G.A.: Feeling and self-awareness. *Psyc. Rev.* **9**(6), 570 – 596 (1902)
383. Tesauro, G.: Reinforcement learning in autonomic computing: A manifesto and case studies. *IEEE Internet Computing* **11**(1), 22–30 (2007)
384. Thomas, D., Luk, W.: Non-uniform random number generation through piecewise linear approximations. In: *Proceedings of the International Conference on Field Programmable Logic and Applications (FPL)*, pp. 1–6 (2006)
385. Thomas, D.B., Luk, W.: Credit Risk Modelling using Hardware Accelerated Monte-Carlo Simulation. In: *Proceedings of the 16th IEEE International Symposium on Field-Programmable Custom Computing Machines (FCCM)*, pp. 229–238 (2008)
386. Todman, T., Boehm, P., Luk, W.: Verification of streaming hardware and software code-signs. In: *Proceedings of the International Conference on Field Programmable Technology (ICFPT)*, pp. 147–150. IEEE (2012)
387. Todman, T., Stilkerich, S.C., Luk, W.: Using Statistical Assertions to Guide Self-Adaptive Systems. *International Journal of Reconfigurable Computing* **2014**, 1–8 (2014). DOI 10.1155/2014/724585
388. Tong, X., Ngai, E.: A ubiquitous publish/subscribe platform for wireless sensor networks with mobile mules. In: *Proceedings of the IEEE Eighth International Conference on Distributed Computing in Sensor Systems (DCOSS)*, pp. 99–108 (2012)
389. Torresen, J., Hafting, Y., Nymoen, K.: A new Wi-Fi based platform for wireless sensor data collection. In: *Proceedings of the International Conference on New Interfaces for Musical Expression*, pp. 337–340 (2013)
390. Torresen, J., Plessl, C., Yao, X.: Special Issue on “Self-Aware and Self-Expressive Systems”. *IEEE Computer* **48**(7), 45–51 (2015)
391. Touch, J., Pingali, V.: The RNA Metaprotocol. In: *Proceedings of the International Conference on Computer Communications and Networks*, pp. 1–6 (2008). DOI 10.1109/ICCCN.2008.ECP.46
392. Trucco, E., Plakas, K.: Video Tracking: A Concise Survey. *Journal of Oceanic Engineering* **31**(2), 520–529 (2006)
393. Tse, A.H.T., Chow, G.C.T., Jin, Q., Thomas, D.B., Luk, W.: Optimising performance of quadrature methods with reduced precision. In: *Proceedings of the International Conference on Reconfigurable Computing: Architectures, Tools and Applications (ARC), Lecture Notes in Computer Science*, vol. 7199, pp. 251–263. Springer (2012). DOI 10.1007/978-3-642-28365-9_21
394. Tse, A.H.T., Thomas, D.B., Tsoi, K.H., Luk, W.: Dynamic scheduling Monte-Carlo framework for multi-accelerator heterogeneous clusters. In: *Proceedings of the International Conference on Field-Programmable Technology (FTP)*, pp. 233–240 (2010)
395. Tsoi, K.H., Luk, W.: Axel: A Heterogeneous Cluster with FPGAs and GPUs. In: *Proceedings of the 18th annual ACM/SIGDA International Symposium on Field Programmable Gate Arrays*, pp. 115–124 (2010)
396. Tsymbal, A., Pechenizkiy, M., Cunningham, P., Puuronen, S.: Dynamic integration of classifiers for handling concept drift. *Information Fusion* **9**(1), 56–68 (2008)
397. Vassev, E., Hinchey, M.: Knowledge representation and awareness in autonomic service-component ensembles – state of the art. In: *14th IEEE International Symposium on Object/Component/Service-oriented Real-time Distributed Computing*, pp. 110–119 (2011)
398. Vasudevan, S.: What is assertion-based verification? *SIGDA E-News* **42**(12) (2012)
399. Vermorel, J., Mohri, M.: Multi-Armed Bandit Algorithms and Empirical Evaluation. In: *Proceedings of the European Conference on Machine Learning*, pp. 437–448. Springer (2005)
400. Vickrey, W.: Counterspeculation, auctions, and competitive sealed tenders. *The Journal of Finance* **16**(1), 8–37 (1961)

401. Vinoski, S.: CORBA: Integrating diverse applications within distributed heterogeneous environments. *IEEE Communications Magazine* **35**(2), 46–55 (1997)
402. Volker, L., Martin, D., El Khayaut, I., Werle, C., Zitterbart, M.: A Node Architecture for 1000 Future Networks. In: *Proceedings of the IEEE International Conference on Communications (ICC)*, pp. 1–5 (2009). DOI 10.1109/ICCW.2009.5207996
403. Volker, L., Martin, D., Werle, C., Zitterbart, M., El-Khayat, I.: Selecting Concurrent Network Architectures at Runtime. In: *Proceedings of the IEEE International Conference on Communications (ICC)*, pp. 1–5 (2009). DOI 10.1109/ICC.2009.5199445
404. Wang, J., Brady, D., Baclawski, K., Kokar, M., Lechowicz, L.: The use of ontologies for the self-awareness of the communication nodes. In: *Proceedings of the Software Defined Radio Technical Conference (SDR)*, vol. 3 (2003)
405. Wang, S., Minku, L.L., Yao, X.: A learning framework for online class imbalance learning. In: *Proceedings of the IEEE Symposium on Computational Intelligence and Ensemble Learning (CIEL)*, pp. 36–45 (2013)
406. Wang, S., Minku, L.L., Yao, X.: Online class imbalance learning and its applications in fault detection. *International Journal of Computational Intelligence and Applications* **12**(1340001), (1–19) (2013)
407. Wang, S., Minku, L.L., Yao, X.: A multi-objective ensemble method for online class imbalance learning. In: *Proceedings of the International Joint Conference on Neural Networks (IJCNN)*, pp. 3311–3318. IEEE (2014). DOI 10.1109/IJCNN.2014.6889545
408. Wang, S., Minku, L.L., Yao, X.: Resampling-based ensemble methods for online class imbalance learning. In: *IEEE Transactions on Knowledge and Data Engineering*, vol. 27, pp. 1356–1368. IEEE (2015). DOI 10.1109/TKDE.2014.2345380
409. Wang, Z., Tang, K., Yao, X.: A memetic algorithm for multi-level redundancy allocation. *IEEE Transactions on Reliability* **59**(4), 754–765 (2010)
410. Watson, R.: The Delta-t Transport Protocol: Features and Experience. In: *Proceedings 14th Conference on Local Computer Networks*, pp. 399–407 (1989). DOI 10.1109/LCN.1989.65288
411. Werner-Allen, G., Tewari, G., Patel, A., Welsh, M., Nagpal, R.: Firefly-inspired sensor network synchronicity with realistic radio effects. In: *Proceedings of the 3rd International Conference on Embedded Networked Sensor Systems*, pp. 142–153 (2005)
412. Weyns, D., Schmerl, B., Grassi, V., Malek, S., Mirandola, R., Prehofer, C., Wuttke, J., Andersson, J., Giese, H., Gäschka, K.M.: On patterns for decentralized control in self-adaptive systems. In: R. Lemos, H. Giese, H. Müller, M. Shaw (eds.) *Software Engineering for Self-Adaptive Systems II, Lecture Notes in Computer Science*, vol. 7475, pp. 76–107. Springer Berlin Heidelberg (2013)
413. Wikipedia: Adaptation (computer science). <http://en.wikipedia.org/wiki/Adaptation>. (Accessed March 8, 2016)
414. Winfield, A.: Robots with internal models: a route to self-aware and hence safer robots. In: J. Pitt (ed.) *The Computer After Me*. Imperial College Press / World Scientific Book (2014)
415. Wolf, W., Ozer, B., Lv, T.: Smart Cameras as Embedded Systems. *IEEE Computer* **35**(9), 48–53 (2002)
416. Wright, M.: Open Sound Control: an enabling technology for musical networking. *Organised Sound* **10**(3), 193–200 (2005)
417. Xiao, L., Zhu, Y., Ni, L., Xu, Z.: GridIS: An Incentive-Based Grid Scheduling. In: *Proceedings of the 19th IEEE International Parallel and Distributed Processing Symposium*, p. 65b (2005). DOI 10.1109/IPDPS.2005.237
418. Xilinx: SDAccel Development Environment. <http://www.xilinx.com/products/design-tools/sdx/sdaccel.html>. (Accessed March 8, 2016)
419. Ye, J., Dobson, S., McKeever, S.: Situation identification techniques in pervasive computing: A review. *Pervasive and Mobile Computing* **8**(1) (2012)
420. Yiannacouras, P., Steffan, J.G., Rose, J.: VESPA: portable, scalable, and flexible FPGA-based vector processors. In: *Proceedings of the International Conference on Compilers, Architecture, and Synthesis for Embedded Systems*, pp. 61–70 (2008)

421. Yilmaz, A., Javed, O., Shah, M.: Object Tracking: A Survey. *ACM Computing Surveys* **38**(4), 1–45 (2006)
422. Yin, F., D., M., Velastin, S.: Performance evaluation of object tracking algorithms. In: Proceedings of the International Workshop on Performance Evaluation of Tracking and Surveillance (2007)
423. Yin, L., Dong, M., Duan, Y., Deng, W., Zhao, K., Guo, J.: A high-performance training-free approach for hand gesture recognition with accelerometer. *Multimedia Tools and Applications* pp. 1–22 (2013)
424. Yu, X., Tang, K., Chen, T., Yao, X.: Empirical analysis of evolutionary algorithms with immigrants schemes for dynamic optimization. *Memetic Computing* **1**(1), 3–24 (2009)
425. Zadeh, L.: Optimality and non-scalar-valued performance criteria. *IEEE Transactions on Automatic Control* **8**(1), 59–60 (1963)
426. Zagal, J.C., Lipson, H.: Towards self-reflecting machines: Two-minds in one robot. In: Advances in Artificial Life. Darwin Meets von Neumann, *Lecture Notes in Computer Science*, vol. 5777, pp. 156–164. Springer (2011)
427. Zambonelli, F., Biccocchi, N., Cabri, G., Leonardi, L., Puviani, M.: On self-adaptation, self-expression, and self-awareness in autonomic service component ensembles. In: Proceedings of the Fifth IEEE Conference on Self-Adaptive and Self-Organizing Systems Workshops (SASOW), pp. 108–113 (2011)
428. Zarezadeh, A.A., Bobda, C.: Hardware Middleware for Person Tracking on Embedded Distributed Smart Cameras. *Hindawi International Journal of Reconfigurable Computing* (2012)
429. Zeppenfeld, J., Bouajila, A., Stechele, W., Bernauer, A., Bringmann, O., Rosenstiel, W., Herkersdorf, A.: Applying ASoC to Multi-core Applications for Workload Management. In: C. Müller-Schloer, H. Schmeck, T. Ungerer (eds.) *Organic Computing – A Paradigm Shift for Complex Systems, Autonomic Systems*, vol. 1, pp. 461–472. Springer Basel (2011)
430. Zhou, A., Qu, B.Y., Li, H., Zhao, S.Z., Suganthan, P.N., Zhang, Q.: Multiobjective evolutionary algorithms: A survey of the state of the art. *Swarm and Evolutionary Computation* **1**(1), 32–49 (2011)
431. Ziliani, F., Velastin, S., Porikli, F., Marcenaro, L., Kelliher, T., Cavallaro, A., Bruneaut, P.: Performance evaluation of event detection solutions: the CREDS experience. In: Proceedings of the International Conference on Advanced Video and Signal Based Surveillance, pp. 201–206 (2005)
432. Zitzler, E., Deb, K., Thiele, L.: Comparison of Multiobjective Evolutionary Algorithm: Empirical Results. *Evolutionary Computation* **8**(2), 173–195 (2000)
433. Zitzler, E., Künzli, S.: Indicator-Based Selection in Multiobjective Search. In: Proceedings of the International Conference on Parallel Problem Solving from Nature (PPSN), vol. 3242, pp. 832–842 (2004)
434. Zitzler, E., Laumanns, M., Thiele, L.: SPEA2: Improving the Strength Pareto Evolutionary Algorithm. Tech. Rep. 103, Computer Engineering and Networks Laboratory (TIK), Swiss Federal Institute of Technology (ETH), Zurich (2001)
435. Zitzler, E., Thiele, L.: Multiobjective evolutionary algorithms: a comparative case study and the strength Pareto approach. *IEEE Transactions on Evolutionary Computation* **3**(4), 257–271 (1999)
436. Zitzler, E., Thiele, L., Laumanns, M., Fonseca, C.M., da Fonseca, V.G.: Performance assessment of multiobjective optimizers: An analysis and review. *IEEE Transactions on Evolutionary Computation* **7**(2), 117–132 (2003)