Bot Theory: A Concise Introduction

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Abstract

This publication was created to establish a firm foundation in understanding what bots are in terms of their theoretical fundamentals. This will help the reader understand what bots are, how they work, and how and where they can be extended. Additionally, we want to provide readers with jumping off points to particular areas of study for further research and investigation. Our end goal is to define the scope, components, architecture, and relationships of bots and their medium.

Nomenclature

The name we choose to call this idea depends on what is in vogue, and what the context is. Currently, “bots” are a popular name, but in the past “agents” have been used, as well as “bot-agents.” The name “agents” are typically used in Artificial Intelligence and Robotics research and can refer to both hardware and software, sometimes also referred to as “actors.” You can think of the taxonomy from most to least abstract: Actors -> Agents -> Bots

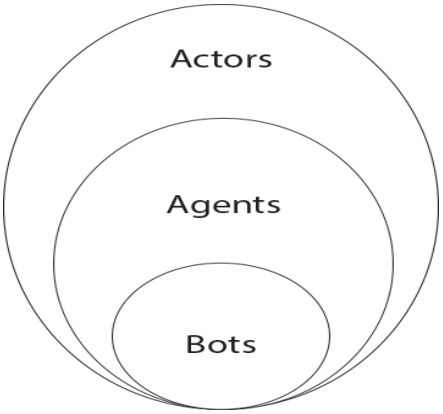

Figure 1. Hierarchy of nomenclature for various terms.

For the sake of this publication we shall henceforth refer to them as, “bots”.

Bots in this context are ultimately pieces of software with variable levels of intelligence that have some directive in mind to accomplish a predefined task at triggered or self-observed intervals and events.

There are a few scopes to consider relative to the bot, namely the medium, system, model, architecture, and operational components.

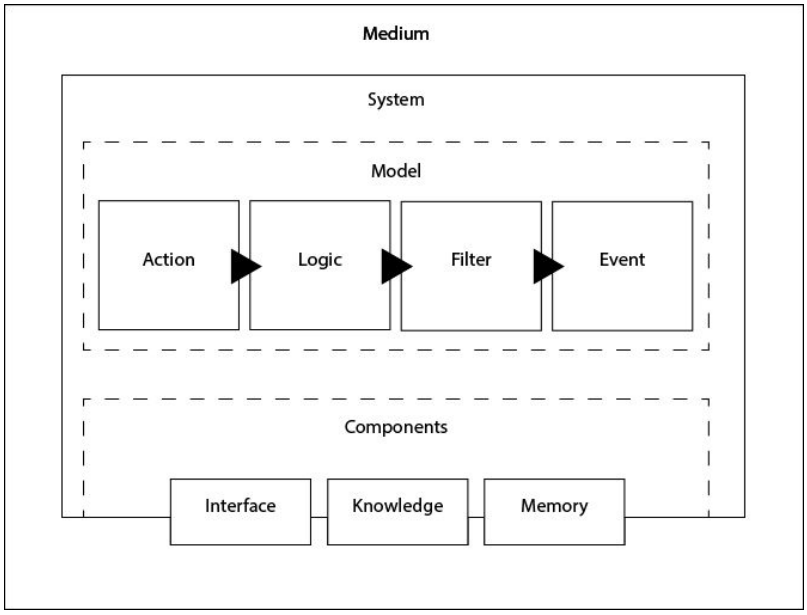

Figure 2. Representation of components that make up the bot and its relationships

Architecture

The two architectures I will describe below are the ASI (Agent-Service-Interface) architecture, and the Autonomous architecture.

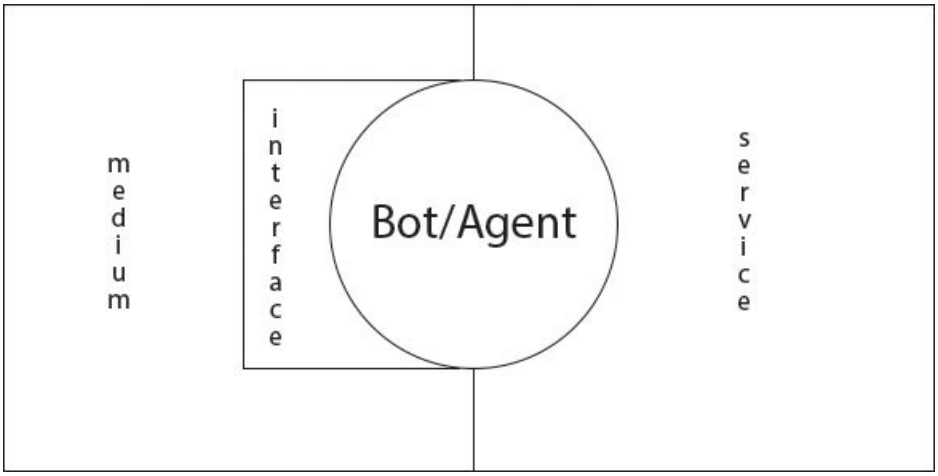

Figure 3. The ASI (Agent-Service-Interface) architecture model

ASI architecture describes the bot system and its relationships. The bot sits and acts as an intermediary for transactions occurring through a service and offers/interprets an interface for other bots (or actors) within that system. Typically the directives of the bot are dictated by the intent of the service it sits in front of.

Autonomous architecture usually has no particular service by which it must accept directives for operation. Its main objective is self preservation.

Medium

We define the medium as the place where the interface, through which, the bot operates externally. This can be either the virtual/digital or physical worlds. The interface can be physical or digital as well, and is typically defined to accommodate the operator that is running it. Interfaces can be thought of as Human-to-Computer, Computer-to-Computer, but ultimately are System-to-System.

A bot is not constrained to a single interface and may include multiple interfaces simultaneously by which it transmits or receives input and output to influence, or as a direct result of, its operation.

System

The System is defined as the abstraction of all simultaneous components together. It is comprised of the components that make up the pieces necessary (but sometimes optional) for a bot to exist. These system components include Interface, Knowledge, Memory, and Model. (IKMM)

The Interface acts to facilitate interaction between both similar and disparate systems and modes. The interface can be defined both rigidly or dynamic. Rigidly defined interfaces for bots are called “APIs” (Application Programming Interfaces). These definitions instruct how one actor in a system can transact with another.

Knowledge is a bit more vague of a concept. It ultimately is an ontology and can contain ideas about the bot and the universe around it. Typically for smaller bot applications, knowledge of other actors, their interfaces, and their locations are all that is needed. Knowledge can exist locally, remotely, or both simultaneously. Knowledge can be probabilistic or statically defined.

Memory is the current working state of internal and external actors, interfaces, and transactions.

The Model is the implemented architecture by which a bot transacts and operates.

Model

The abstract model can be seen at first as a processing pipeline comprised of multiple stages. The ALFE (Action->Logic->Filter->Event) model describes each stage of the pipeline.

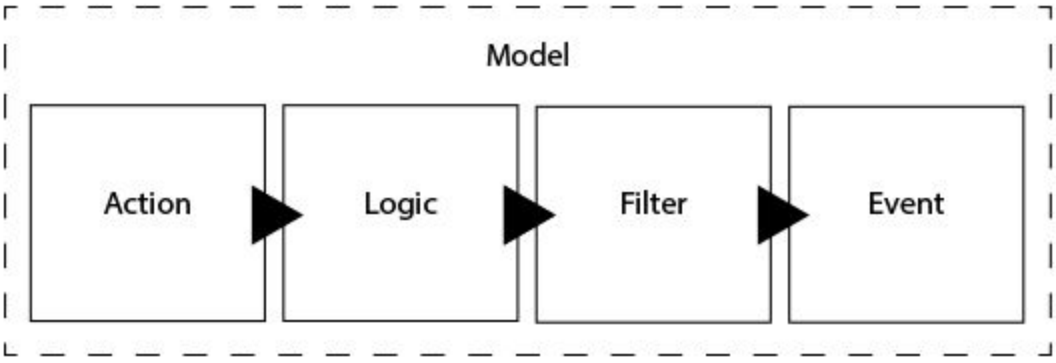

Figure 4. The ALFE (Action->Logic->Filter->Event) bot processing model

The Action stage refers to the active piece of the bot engaging with some target/actor through the interface of the system. An example action might be *“Watch this thing”.*

The Logic stage refers to the conditional logic required to determine if the input from the action stage is valid. *“Did this thing we watched change?”*

The Filter stage is used to clean up and format some input results. *“We now want to present the thing that changed in a way that makes sense to another interface”*

The Event stage is how the bot will take that filtered data and update and coordinate with other actors across its medium. *“Send the formatted results to an observer through email”*

Each stage can internally grow in complexity. The pipeline also does not need to exist linearly based on the requirements of the bot and the responsibilities of the stages during processing. For instance, you can have each stage contain additional logic that can control other stages and their parameters for processing. These stages can also be made to be recursive pieces. In addition these stages can also be abstracted and distributed horizontally across multiple bots with the same concerns.

Each stage should be considered as a tunable component if required. Tuning each stage through feedback and understanding can lead to intelligent systems.

Additional topics

Collaborative or Multi-agent systems

Coordinated bots acting in unison to accomplish a task is considered a Multi-Agent System (MAS). This can also be called a “botnet.” These bots typically communicate remotely or locally, have knowledge of state (both globally, and personally). The bots can decide based on democratic processes, or be coordinated by an master/slave hierarchical communication architecture.

Bots participating as part of the MAS can have overlapping objectives with specific functions of the task each must pursue, or all bots within the system can have the same function in which all bots try to converge on an equilibrium state as dictated by their objectives and task.

Intelligence, Agency, Personhood

Intelligence (in our context) is an emergent feature that combines both knowledge (ontology) and wisdom (models) of systems and interfaces to produce a desired outcome through some level of autonomy. (This does not described perceived intelligence from a human/conversational/explanatory perspective.)

Intelligence can be contained within and throughout any stage of our architecture. Stage parameters can be tuned through statistical analysis of inputs and outputs relative to their

respective directives and tasks. We can create machine learning models that help bots to better approximate, anticipate, and adapt to their environments, creating a robust architecture for our bot and providing some level of agency to more accurately accomplish its task autonomously.

About the author

Dan P. Gailey, B.Sc. Electrical Engineering (Robotics); Computational Chemistry. Dan has held positions with The National Center for Physical Acoustics, Make Magazine, and E.Ventures (Venture Capital). He founded Baqqer (a maker community), Techendo (a tech review site), Pule (a bot company), and most recently Asteria (an AI companion device). In addition to this he acts as a mentor to entrepreneurs and holds advisory roles for startups around the world.