TABLE V
SOFTWARE ARCHITECTURES FOR AGRICULTURAL ROBOT FOR DIFFERENT APPLICATIONS

Application areas	Type of robots	Crops/animals	Production cycle/task	References	Architecture/Pattern
Arable farming	AGV	–	Ploughing, seeding, fertilizing, etc.	[30]	Subsumption architecture
	AGV	–	Navigation in the crop field	[28]	Hybrid architecture
	Heterogeneous, AAV, and AGV	–	Weed management	[31]	Distributed and hierarchical architecture
	AGV	–	Navigation for precision farming	[32]	Sense–plan–act
	AGV	–	Processing and monitoring field	[33]	Cloud-based
	AGV	–	monitoring and scheduling	[34]	Lambda architecture (LambdAgrIoT)
	AGV	–	Big data processing	[35]	cloud-based
	AGV	Wheat/maize	Weed management	[36]	FIWARE and Apache Kafka-based
Horticulture	–	–	Greenhouse harvesting	[29]	Distributed architecture for mobile navigation
	AGV	Orange	Orchard image data collection	[37]	Distributed high level architecture-based
	AGV	Vineyards	Navigation	[38]	Deliberative architecture
	AGV	Vineyards	Navigation	[39]	Ethical architecture
	AGV	–	Navigation of fleet of mobile robots	[40]	Distribute and hybrid architecture
	AGV	Lettuce and tomato	Weed management	[41], [42]	Sense--plan–act
	AGV mounted AAR	Cherry tomato	Greenhouse harvesting	[43]	Sense--plan–act
	AGV mounted AAR	Apple	Orchard harvesting	[44], [45]	Sense--plan–act
	AGV mounted AAR	Orange	Orchard harvesting	[46], [47]	Sense--plan–act
	AGV mounted with manipulator	Pepper	Greenhouse harvesting	[48], [49]	Sense--plan–act
Animal husbandry	IoT-based	Cow	Methane emissions	[50]	Azure cloud platform
	AAVs	Cattle/sheep	Monitoring	[51], [52], [53]	Layered architecture
	AAVs	Cattle/sheep	Monitoring	[54]	FANETs architecture
	Mobile robot	–	Service purpose	[55]	Distributed architecture
Food processing	AAR	3-D printed objects	Sorting	[56]	Microservices architecture
	AAR	Pork	Pork cutting	[57]	Physical human-robot architecture
	AAR	Poultry	Pick and place of meat pieces	[58]	Sense–plan–act architecture
	AAR	Fish	Fish pick and place	[59]	Sense–plan–act architecture
	AAR	Salmon fish	Remove pin bones of the fillet	[60]	Sense–plan–act architecture
	AAR	Poultry	Rehang whole bird	[61]	hybrid distributed architecture
Food packaging	Delta robot	Fish	Fish fillet packing	[60]	Distributed architecture
	Delta robot	Poultry	Poultry fillet packing	[61]	Distributed architecture

robots ([43]), apple harvesting robots ([44], [45]), orange harvesting robots ([46], [47]), and sweet peppers harvesting robots ([48], [49]), weed management robots ([41], [62]). However, the majority of previous research has been put to the test in either a simulation ([63], [64]) or in a laboratory environment ([46]). Very few works have been tested in real-world field environment ([41], [49], [65], [66]). In addition, the architecture for these works follows the conventional sense–plan–act paradigm. There is a small amount of work that is focused on the learning model, which is to learn a new world on one's own and behave accordingly.

3) *Animal husbandry:* IoT-based architectures are used for tasks related to monitoring cow methane emissions. Layered architecture [52] and flying ad hoc networks (FANETs) architecture [54] are employed for cattle and sheep monitoring. The drone is envisioned as operating at the edge in the proposed design, and its built-in processing power may be utilized. [53] also proposed a layered architecture for livestock management. FANET are frequently created by connecting many UAVs [54]. High-speed (30 to 460 km/h) and 3-D movable nodes are characteristics of FANET. FANETs have particular design and protocol constraints because of the mobility and restricted resources of UAVs. Service robots are being used more and more in agriculture. They work in both agriculture and animal husbandry. Chikurtev [55] presented a distributed software architecture for controlling a modular service robot for animal husbandry. The purpose of this design was to allow interinstalled module communication. Services and microservices are the foundation for the requests and replies that are exchanged between the various components.
4) *Food processing:* AARs are employed for various food processing tasks. Microservices architecture, physical human–robot architecture, sense–plan–act architecture, and hybrid distributed architecture are applied for tasks, such as sorting, pork cutting, meat piece pick-and-place, fish handling, and salmon fillet processing. The microservices architecture is utilized for the removal of pin bones from salmon fillets.